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VOLUME 11 NOVEMBER-DECEMBER, 1961 NUMBER 6

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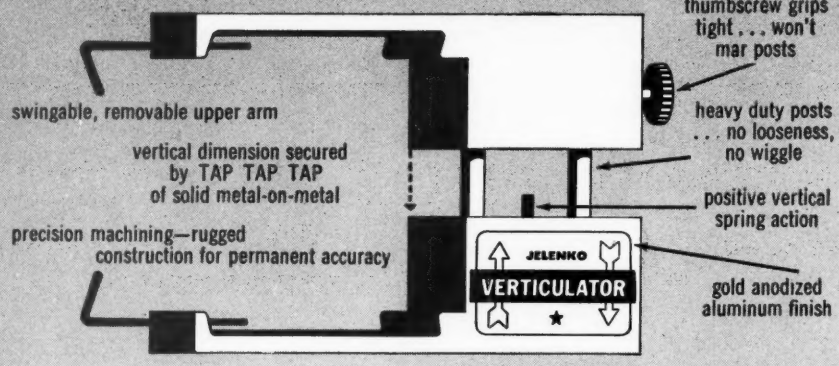
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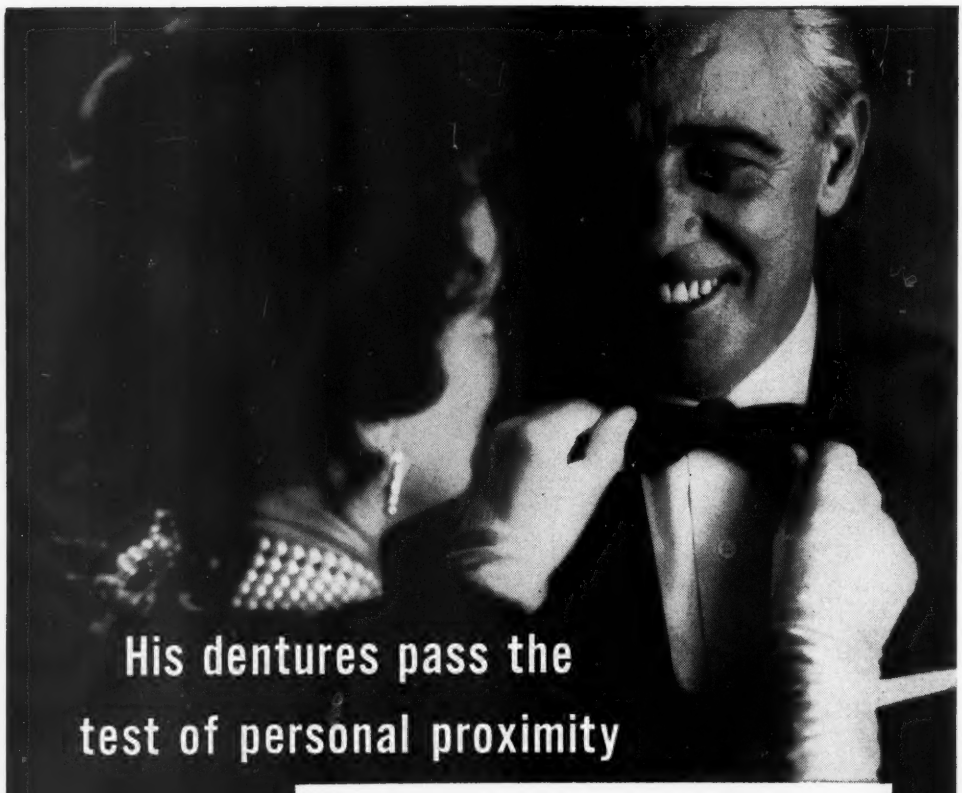

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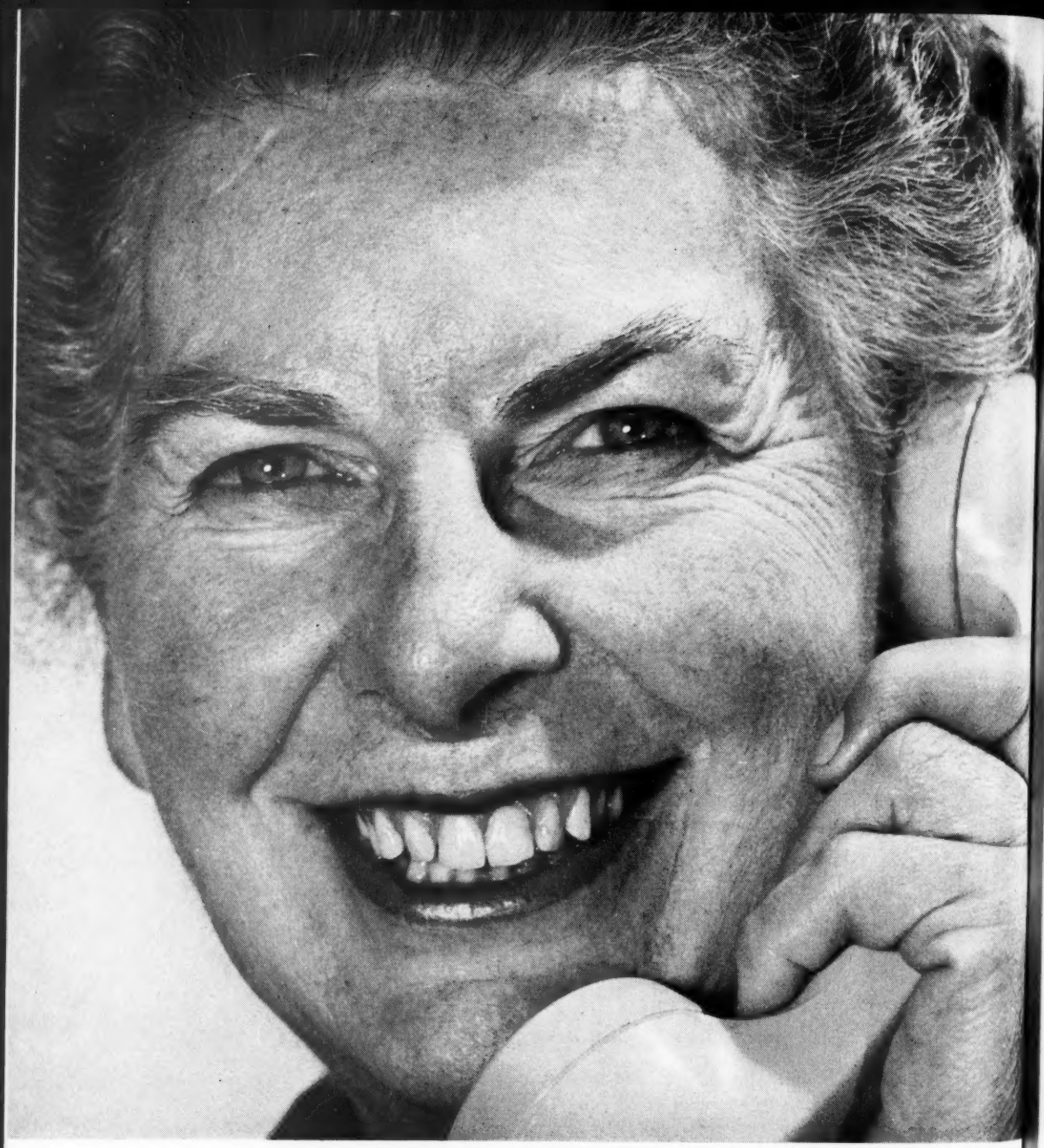

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OPERATIVE DENTISTRY

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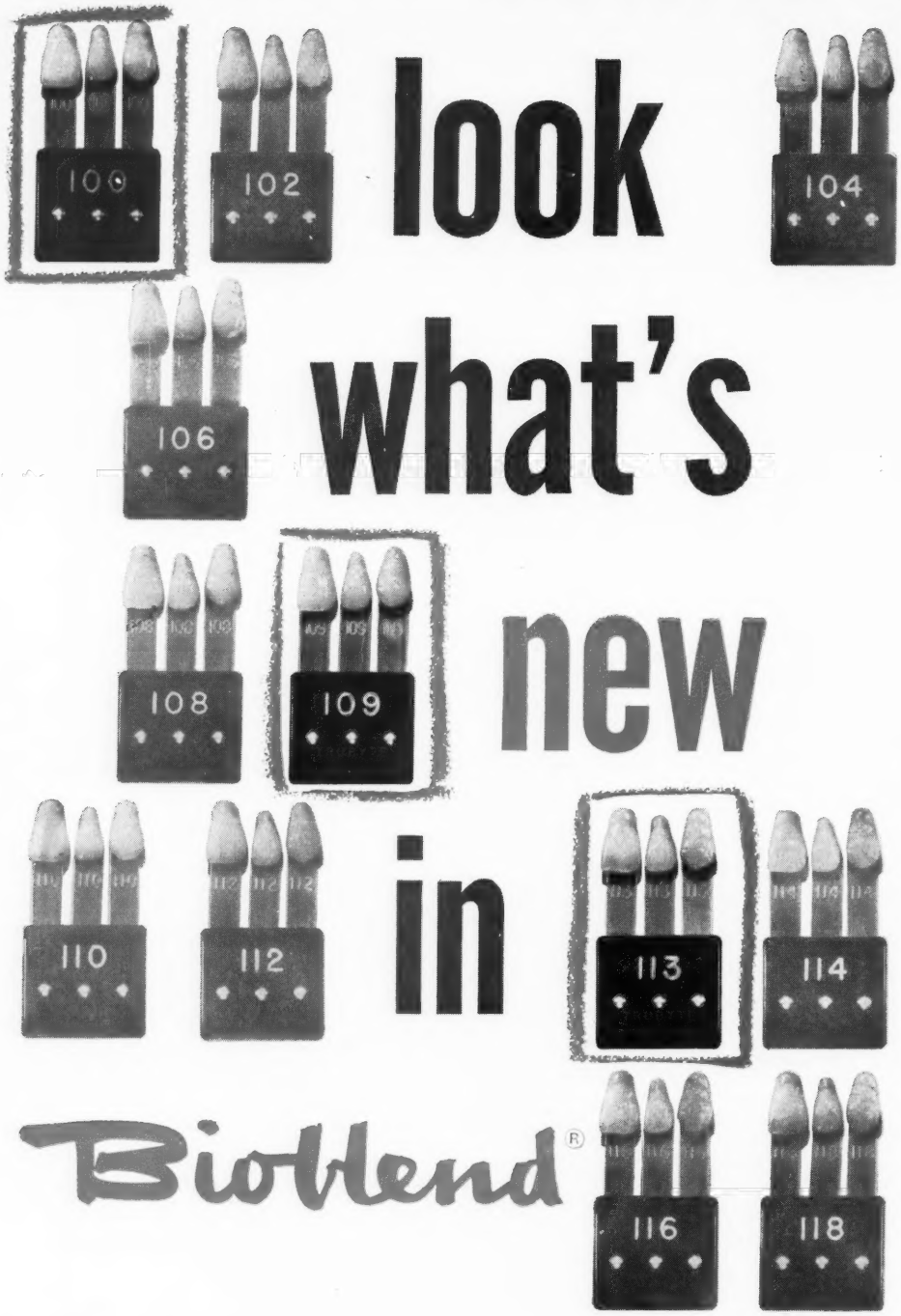

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NOVEMBER-
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NUMBER 6

THROUGH THE EYES OF THE EDITOR

Alexander L. Martone introduces a series of articles in which the many interrelated functions of the mouth and associated structures are discussed. He designates the region of concern to dentists as the pyramid of polyfunction. This approach simplifies the detailed discussion of the prosthodontic significance of the region and its relation to anatomy, speech, and mastication.

Alexander L. Martone and Linden F. Edwards discuss the anatomic and prosthodontic significance of the surface markings of the face and describe the facial musculature that is responsible for the surface markings. They point out a means whereby the dentist can judge the vitality of the facial tissues of a patient and thus estimate the esthetic possibilities of prosthodontic service for him. Each of the facial muscles has its own responsibility for facial expression, and if all of these muscles are not properly supported, their tone and activity will be changed. These changes are apparent if the face of the patient is studied.

A. Langer, J. Michman, and I. Seifert report their studies of factors which influence the reactions of geriatric patients to dentures. The statistical analysis of the results with patients in four homes for the aged indicates that the ability to eat and comfort were the most important factors in success. The chewing efficiency tests and the clinical fit of dentures (as judged by dentists) could not be correlated with patient satisfaction. They point out the fact, however, that the patients had no choice of dentist and suggest that this may have a signficant influence on the evaluations made by patients.

Arthur R. Frechette reports his studies of the effect of changes of relative tooth positions on the stability of dentures. He used electronic strain gauges on a maxillary denture base with interchangeable occlusal segments to measure the forces applied when the teeth were set in normal and cross-bite relations. He states that further tests will be required before conclusions can be drawn. The method of study does offer promising possibilities.

W. Alan Lawson discusses the relationship of the sublingual fold to the anterior part of the lingual flange of lower dentures and suggests border molding procedures to obtain maximal benefits from them. The technique develops both the length and the thickness of the lingual flange so it will reach the movable tissues at all functional levels and also permit them to move in a normal manner. The great variation found in the structures in the anterior part of the floor of the mouth dictates the use of procedures which make the denture conform to their individual peculiarities.

Anders Olsson and Ulf Posselt report their investigation of the relationships between various reference lines of the skull and compare their results with those obtained by other investigators. They point out the variations ob-

tained by others and suggest that the use of different methods has caused the variation. The results can be valuable, for example, when the angulation of the condylar guidance is being considered. It is apparent that the inclination of the condylar guidance must be related to some other line or plane. Thus, there must be a perfect understanding of the orientation to the line or plane of reference, and this is now possible.

H. W. Fountain describes his methods for recording centric relation. He does not use force on the mandible when the interocclusal records are made, but he makes the records after the patient clenches the teeth on a modeling compound index to condition the neuromuscular system. He feels that his procedure puts the condyles in their most posterior and superior position and establishes an equilibrium of the musculature and the temporomandibular joints. After the conditioning is complete, the final interocclusal records are made with a zinc oxide–eugenol cement.

Honorato Villa A. discusses the circular rotational movements of the mandible and correlates them with the elliptic movements he has described. His separation of the many complex mandibular movements into their components is an interesting approach to the problems of occlusion. The method for locating the mandibular hinge axis appears to be a variation of one in which a series of interocclusal records is made at various occlusal levels.

Arne G. Lauritzen and Lloyd W. Wolford have devised an instrument for testing the ability of an operator to locate the true axis of movement of an arm rotating through a small range of movement. The test involves factors of observation similar to those used for locating a hinge axis point on a patient's face. Their results indicate that the center of rotation can be located with a 10 degree range of movement to an accuracy of 0.2 mm. These tests take into account only the mechanical location of the point, and while the problem is related to that on a patient's face, they were not intended to include the biologic factors involved in a hinge axis location.

Harry Robert Sönstebö studied the recordings of mandibular movements made by C. E. Luce more than 60 years ago and compared them with recordings made by contemporary investigators. Luce used a photographic method, and the movements he selected for examination were similar to those being used today. Even though the tracings of border movements are similar, as would be expected, Luce apparently did not make note of the significance of the posterior border movement.

Harry Robert Sönstebö calls attention to the work of W. E. Walker, who was a leader in prosthetic thinking before 1900. Walker's work included improvements in the concept and design of teeth, articulators, and occlusion. It is apparent that even 60 years ago, dentists were concerned with the same problems as they are now. Some of the concepts of that time appear to be valid today.

Robert W. Shippee reports his studies of the effect of variations in flasking and processing techniques on changes in dentures which occur during processing. The vertical dimension of occlusion was measured on the articulator before and after processing, but before the dentures were removed from the casts. Significant increases were found, which indicate that the occlusion of dentures must be corrected before the dentures are inserted or at the time of insertion. He suggests the use of escapements in the flask in order to reduce the change by 50 per cent. The resin expands during polymerization, and the escapements apparently provide space for the excess material. This should help if the procedure is properly carried out.

Franklin W. Smith and Oliver C. Applegate report the use of roentgenograms and photographic analyses for determining the changes in bone in edentulous areas. They use exercise prostheses for stimulation of the bone underlying partial dentures. As the treatment continues, roentgenograms are made periodically, and the density of the films is graded and compared with the original roentgenograms. The changes in density indicate the progress of the recovery of the bone from its condition resulting from disuse. The light intermittent stimulation over a long period of time seems to be effective.

Eugene J. Tillman discusses the problems related to the construction of complete lower dentures opposed by partial upper dentures and describes his technique for making these restorations. He points out the impression, jaw relations, and occlusion as the critical phases of the procedure. The ultimate of skill and design must be used for patients with an

edentulous mandible and partially edentulous maxillae. The fact of a more firm foundation in the upper jaw than in the lower one contributes to a tendency for these patients to use too much force in the mastication of food. If this occurs, the bone of the mandible is in jeopardy. The suggestions made in this article will aid in reducing the potential danger, but if the bone of the mandible has a tendency toward rapid resorption, it seems more logical to make complete upper and lower dentures. Thus, the total force applied in function is likely to be reduced and the bone of the mandible protected from excessive pressure.

J. Allan Warr discusses clasp design and suggests a mathematical method for considering all of the factors involved in their proper relation to each other and in the total result. Once the mathematics of the system is understood, the total values can be used to indicate the proper specifications for each clasp on a partial denture. The numerous variables involved in clasp design are pointed out in this article.

William H. Dietz describes various modifications of standard preparations which may be made to protect defective teeth so they can be used as abutments. Such situations occur frequently, and these restorations can be used to conserve tooth structure and prevent further damage to crucial teeth.

Leonard I. Linkow discusses the advantages and indications for splinting all of the teeth in an arch together and suggests specifications for the construction of these extensive restorations. He uses as abutments some teeth that might be lost if they did not have support from others in the rigid fixed partial denture. The design can be effective because the abutment teeth are not in a straight line. This type of work must be carried out with meticulous care and accuracy if it is to be successful.

Victor E. Wasser suggests that a plastic steel can be used for dies and describes his technique for using it. The material is stronger and much more durable than ordinary dental die and cast materials but does have some disadvantages.

Basil G. Bibby discusses three factors that affect caries resistance of teeth. These are related to the environment of the teeth. He cites the preventive action of fluorine in public water supplies and topical application on the enamel surface as a result of a change in environment. He points out the fact that diets with varying amounts of carbohydrates also change the environment and that *frequency* of eating is a factor. He suggests the possibility of controlling dental caries by altering the constituents of saliva.

John H. Nesson discusses the relationship between periodontal health and dental health as a whole. He points out restorative procedures which are intended to promote dental health but which may impair periodontal health. These include unwise decisions regarding the retention of teeth and indiscriminate full coverage splinting of periodontally involved teeth. He suggests the use of more conservative pinledge and three-quarter crown restorations for splinting whenever possible. His plea for sound clinical judgment seems to be timely.

William E. Cody discusses various types of dental treatment for children. He points out the similarity of the problems to those in the treatment of adult patients. He also points out the essential differences in treatment made necessary by the growth and development of a child's tooth and other oral structures. The fact that restorations made for children must be effective for a much longer time than similar restorations for adult patients is significant and indicates the need for special care in treating the tooth of a child.

Kenneth N. Morrison and Myron E. Warnick recommend porcelain inlays for all gingival cavities for reasons of esthetics. They describe their technique of cavity preparation and make use of rubber-base impression materials and a refractory investment for these restorations. These simplified procedures produce more accurate inlays than other techniques and should increase the use of porcelain inlays where they are indicated.

R. H. Killebrew discusses his experiences with subperiosteal implants and points out the reasons for failure of implant dentures. He describes his technique for making these restorations and shows the development of an improved design for the implant substructure. He recommends that soft tissue–borne dentures be worn by patients for at least 2 years before implants are placed and emphasizes the importance of occlusion to the success of these restorations.

David P. Dobson, John B. Sowter, William P. Webster, and Herbert F. Johnson describe a prosthetic appliance they used to treat a squamous cell carcinoma of the maxilla after surgical resection. This illustrates a type of teamwork and cooperation between the dental and medical professions that can produce the best results for patients.

—Carl O. Boucher

A TRIBUTE

JOHN W. GELLER

Dr. John W. Geller of Indianapolis died suddenly on Sunday, June 25, 1961. Dr. Geller was a Contributing Editor of THE JOURNAL OF PROSTHETIC DENTISTRY, but it is not because he held that position that this note to his memory is being written. This memorial note is written in gratitude, respecting the memory of a driving, inspirational force that contributed tremendously to the conception and ultimate birth of this JOURNAL. It was during his term as president of the American Denture Society that Dr. Geller used his organizational genius to set in motion the wheels that put the original publications committees on their way to reaching their primary goal, that of making available to the dental profession a nearly complete picture of the newest and best thinking in prosthetic dentistry.

It was my privilege to serve as temporary chairman of the original group, representing the three founding societies, that later developed into the Editorial Council. I have served as Chairman of the Editorial Council since its formation. Therefore, I have been in a position to see, to know, and to appreciate the contribution of each individual who has been connected in any way with the JOURNAL throughout its history. Dr. Geller has earned lasting respect and a deep sense of appreciation for his contribution. For that service we dedicate this page to his memory.

LOUIS S. BLOCK, D.D.S.
CHAIRMAN, EDITORIAL COUNCIL

THE PHENOMENON OF FUNCTION IN COMPLETE DENTURE PROSTHODONTICS

GENERAL INTRODUCTION

ALEXANDER L. MARTONE, D.D.S., M.Sc.*
Norfolk, Va.

THE ORAL CAVITY lies within an anatomic area extending from the sternum to the tip of the nose and on to the outer orifices of the ears. This area has the shape of an inverted pyramid (Fig. 1). It may well be termed a pyramid of polyfunction since it contains the organs and structures responsible in part or in whole for functions of facial expression, mastication, deglutition, breathing, and speech. The dentist's knowledge of the anatomy of this pyramid and his appreciation of the complexity of the interrelated functions performed there determine the success of the prosthodontic treatment he can give his patients.

In prosthetic literature and research, considerable emphasis has been placed on problems of mastication and deglutition. Far less consideration has been given to the importance of the denture in speech or to a dynamic concept of denture esthetics which is based on an understanding of the vital role the kinesthetic muscles of facial expression play in the projection of the personality of the individual. Actually, all of these functions are of necessary concern to the prosthodontist. His functional evaluation of the prosthesis must be in terms of all of them since all may occur simultaneously or in split-second sequence.

It is the purpose of this series of articles to consider prosthodontic problems related to all of the functions performed within this pyramid (Fig. 1). Primary concern has been accorded the functions of facial expression and speech, and secondary emphasis has been given to mastication, deglutition, and breathing. Such considerations involve (1) a study of the functional anatomy of the mouth and related structures, (2) a review of current information of prosthodontic significance in the field of speech science, and (3) clinical applications of functional anatomy and the science of speech to prosthodontics.

The sciences of anatomy, speech, and prosthodontics are closely related. They may be viewed as components of a pyramid the base of which is the functional anatomy which necessarily limits and determines the scope and progress of the other two fields. Since a prosthodontic appliance must promote the functions of

*Associate, Departments of Prosthodontics and Anatomy, Medical College of Virginia.

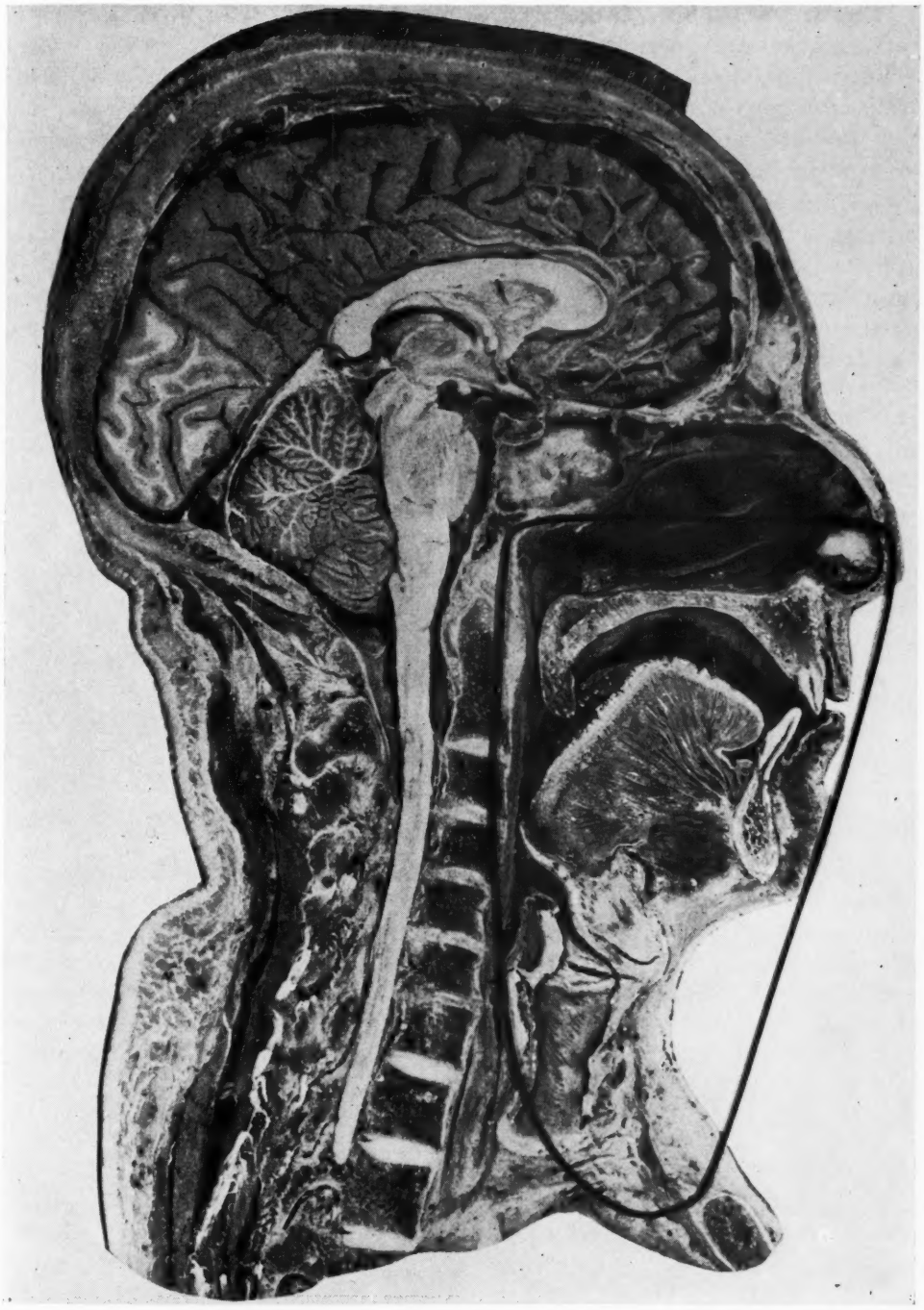

Fig. 1.—A hemisection view of the head and neck regions with the polyfunctional pyramid outlined as it extends from the sternum to the nose and then to the outer orifices of the ear.

expression, both facial and speech, for a much greater percentage of the time than it assists in the function of mastication, it would seem logical to look to a liaison between the fields of prosthodontics and speech science in order to afford a better service to patients. Therefore, this series of articles has been developed by writers whose major interests have been devoted to these related sciences. We have attempted to correlate the significant contributions from these fields in such a way that they will be of practical value to the dentist faced with the problem of creating an inert appliance which must become a functional part of a dynamic organism. In accomplishing this, the dentist is expected to effect a substitute which will attempt to restore functions despite foundational changes which have occurred and will continue to occur, to contribute esthetically to the patient, and to be within health and tolerance ranges of supporting structures. These are the challenges which enter into prosthetic dentistry. These are the reasons why prosthodontics can never be classified as a mechanical art.

ANATOMY OF THE MOUTH AND RELATED STRUCTURES

Part I. The Face*

ALEXANDER L. MARTONE, D.D.S., M.SC.,** AND LINDEN F. EDWARDS, PH.D.***

Norfolk, Va., and Columbus, Ohio

STANDARD TEXTBOOKS on anatomy begin with a consideration of osseous structures, while speech science writings frequently give first emphasis to a study of the thoracic cavity, where speech originates. However, dental diagnosis and prognosis should start when the dentist first views his patient and the patient begins to express himself, by either mannerisms or speech. It is then that the dentist begins to evaluate the prosthetic possibilities and limitations for the patient from the external signs and symptoms of the polyfunctional pyramid, as evidenced in the eye, mouth, and neck regions, and from the speech of the patient. Speech provides, in addition to the ideas conveyed thereby, the opportunity to observe the many facets of the anatomy brought into play during this function. Therefore, it would seem logical that the approach to this study of the anatomy of the mouth and its related structures should be that used in initial diagnostic procedures. Thus, the reader can associate the descriptive anatomy in the structural sequence he is accustomed to use with the prosthodontic considerations which will be suggested.

FACIAL EXAMINATION

The importance of surface anatomy was well stated by Cunningham[1]: "Surface Anatomy fulfills a twin-purpose; it is a description of the topography of the body-surface as influenced by the conformation of superficial structures (including skeletal landmarks), combined with a surface-orientation of related structures that lie at a deeper level. It is therefore the essential basis for the primary physical examination of a patient and for the appreciation of the significance of the symptoms and signs of disease in general" (Fig. 1).

POSSIBILITIES AND LIMITATIONS AS EVIDENCED BY EXTERNAL SIGNS AND SYMPTOMS

A detailed study of the patient's face is both fascinating and revealing (Fig. 1). Such an analysis becomes a most significant diagnostic aid in supplying anatomic data and in reflecting the personality of the patient as evidenced in characteristic facial expressions and speech mannerisms.

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*Part I of a series.

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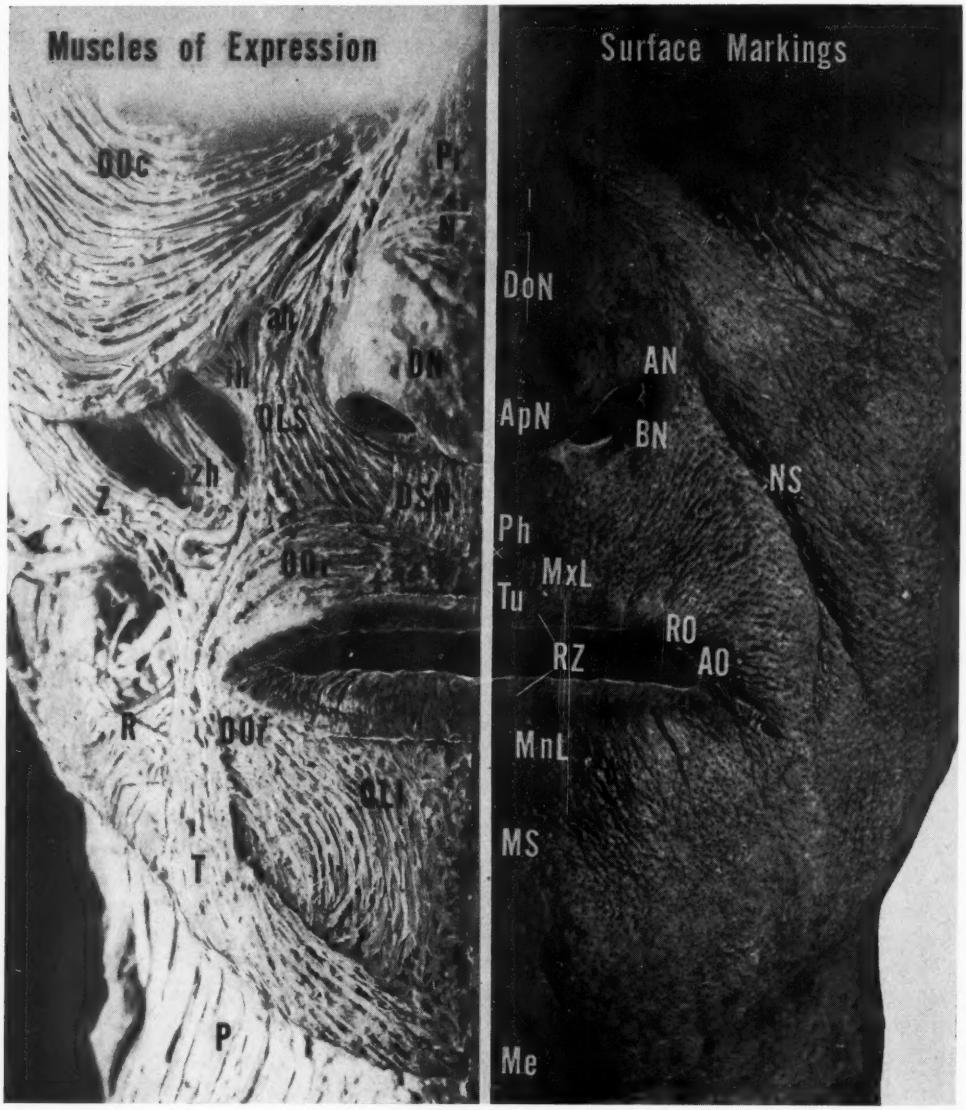

A. *B.*

Fig. 1.—Frontal view of the polyfunctional pyramid. *A*, The underlying superficial musculature: *(OOc)* orbicularis oculi; *(Pr)* procerus; *(N)* nasalis; *(QLS)* quadratus labii superioris; *(ah)* angular head; *(ih)* infraorbital head; *(zh)* zygomatic head; *(DN)* dilator naris; *(DSN)* depressor septi nasi; *(Z)* zygomaticus; *(R)* risorius; *(OOr)* orbicularis oris; *(T)* triangularis; *(QLI)* quadratus labii inferioris; *(P)* platysma. *B*, The surface anatomy: *(DoN)* dorsum nasi; *(AN)* ala nasi; *(ApN)* apex nasi; *(BN)* basis nasi; *(NS)* nasolabial sulcus; *(Ph)* philtrum; *(MxL)* maxillary lip *(Tu)* tubercle; *(RO)* rima oris; *(AO)* angularis oris; *(RZ)* red zone or vermilion border; *(MnL)* mandibular lip; *(MS)* mentolabial sulcus; *(Me)* mentum.

General observations as to the patient's sex, age, skin, tissue tone, and shape of bony structures furnish the initial means for evaluating that patient as an individual. The male patient may evidence certain feminine characteristics, while a

female patient may reflect many masculine overtones (Fig. 2). Such observations of sexual characteristics are essential in making a thorough diagnostic study.

The age factor cannot be dismissed by the mere recording of the chronologic age. It is necessary to consider the age of the patient physiologically (particularly in reference to his dental age), mentally, and emotionally. The disparities which may exist between these various ages in one individual and the influences one age may exert on the others are sometimes most dramatic. This may be observed frequently in young patients who have, through accident, become partially edentulous (Fig. 3, *A*). Ordinarily, there is a correlation between the chronologic age and the physiologic age of an individual, with the corresponding changes associated with the aging process. Edwards[2] describes these changes as occurring "in the facial contour and expression due to the loss of the teeth and their supporting alveolar processes which are resorbed. In addition to the wrinkled skin and sagging tissues, these changes include a reduction of the vertical dimension between the base of the nose and chin and a flattening of the lips with the obliteration of the philtrum and accentuation of the nasolabial sulci" (Fig. 4). However, premature aging may be produced through illness, emotional disturbances, occupational conditions, metabolic effects, or dietary deficiencies. Frequently, this premature aging is reflected in the skin texture and tissue tone of the patient, although wrinkles and deep furrows may also be the result of heredity or habitual facial expressions.

A study of the general shape of the patient's features and bony structures serves as a guide in creation of prosthodontic restorations which will be in harmony with these features.

Preliminary observations such as these can be made when the dentist first views the patient. They are of significance to the trained diagnostician because they become the basis for his detailed study of the facial contours, face, neck, musculature, and teeth.

Various methods for measuring facial proportions and for classifications of facial forms exist. In general, they yield a stereotyped three dimensional study of the patient, rarely taking into account what may be considered the fourth dimension. This is the vitality factor which marks the patient as alive and as a far more complicated subject than the head of a cadaver, for which a three dimensional analysis of static anatomy would be adequate (Fig. 5). The mere recognition of this fourth dimension or vitality factor of the individual patient presents a problem of how to "measure" *functional* anatomy. There are no instruments which can accomplish such measurements. Even the time-consuming procedure of developing a facial mask will produce only a static study of the patient. The objective, then, of a detailed analysis of the patient should be to study the anatomy in action and then to evaluate the findings in the light of their effect on the possibilities and limitations of the treatment for the patient.

Normally, as a person approaches the age of 40, there is a tendency toward an increase in weight. In facial contours, this may result in the development of jowls which may change the general contour of the face from a tapered or ovoid-tapered outline to a square outline. This may be accentuated by a decrease in the vertical dimension of occlusion. In undertaking face-lifting operations, an attempt is made to raise these sagging tissues to restore a more youthful contour. Facial

contours are delineated basically by the heredity of the individual. However, these basic hereditary outlines are subject to the influences of environment and age. Thus, a careful study of the contours may reveal evidences of the individual's occupation, economic or social status, temperament, speech, and eating habits.

The normal grooves, such as the nasolabial and mentolabial sulci, may become deep folds as the result of hereditary tendencies, environmental influences, or aging changes (Figs. 1 and 4). The labiomarginal sulcus, a furrow extending in a posterior convex arch from the corner of the mouth toward the lower portion of the mandible, is not found in the young face but develops with increasing age (Fig. 3).

FACIAL DIVISIONS

The individual features of the face, with the many variations and combinations found in shape, size, skin color and texture, alignment, and arrangement, account for the distinguishing facial characteristics which differentiate one person from another.

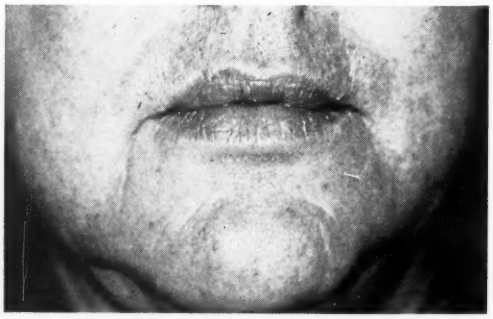

Fig. 2.—A man's mouth which reflects predominantly feminine characteristics of size, shape, and delicacy of contour.

For purposes of description, the face proper and the forehead may be divided into thirds: (1) the superior third, consisting of the forehead, (2) the middle third, composed of the orbital, infraorbital, nasal, zygomatic, and auricular regions, and (3) the inferior third, which comprises the labial, buccal, and mental regions.

Superior Third.—The superior third or forehead region is governed entirely by the shape of the osseous foundation and, unlike other parts of the face, is covered by a uniform thickness of soft tissues. Loss of hair may modify the appearance of the forehead without effecting a contour change; but a strong masticatory apparatus may be responsible for an actual contour variation of this feature by accentuating the frontal superstructure and gradually changing the high forehead of a young individual into a low or receding forehead.[3]

Middle Third.—In the orbital region of the face proper are the eyes, frequently considered the most expressive of the facial features. The size and shape of the eyes, their proximity to each other, and the variations in the eyelids and eyebrows are all contributory to the over-all facial contour. Cosmetic modification of the brows or lashes or the wearing of glasses may either accentuate or minimize the

contours of this region. An anatomically recessed feature, the eye gives depth to the face as a whole. This depth is further accentuated when adjacent structures such as the zygoma, supraorbital arches, and nose are unusually prominent. Located at the lowest point of the infraorbital margin is the orbitale, which serves as a reference point in establishing the Frankfort horizontal plane.

The nasal region of the face is of extreme importance in the facial contour for it includes the external nose, which is a projecting feature, basically resembling a pyramid in shape. Its prominence among the other facial features is increased because of its central position in the face. Racial characteristics are reflected in the nose, and many deviations in both size and shape may be noted. The nasal region affords two anatomic landmarks, the alae and subnasion, which are used as points of reference in registering maxillomandibular relations. The alae form the boundary of the nostrils, and the subnasion is the point of juncture of the lower border of the septum and the maxillary lip.

In the auricular region is located the external ear, another projecting feature of the face. The auricle of the external ear is boneless, and its appearance depends upon the inner cartilaginous plate. The angle formed by the auricle with the side of the head varies in different people. Many individual variations are found in the size and shape of the various eminences and concavities of the auricle. One of these eminences, the tragus, a tonguelike process overlapping the concha and located in the middle anterior part of the external ear, serves as a point of reference in maxillomandibular orientation and registration. The auricle increases dimensionally throughout the individual's life. In senility, when this continued growth is combined with the shrinking of the tissues in other parts of the face, a tremendous change results in the general facial contour of the individual.

A. *B.*

Fig. 3.—Aging changes resulting from loss of teeth. *A*, A young woman partially edentulous because of accident; note the absence of the labiomarginal sulcus. *B*, An older man who is edentulous because of pathosis; note the prominence of the zygomatic region. Similar loss of maxillary lip support is apparent in both patients.

The cheeks lie in both the middle and inferior thirds of the face. Their superior boundary is the orbit, and the zygoma, or malar bone, is responsible for their prominence. Extending into the parotidomasseteric region is the zygomatic arch. The most lateral projection of this arch is the zygion, a prosthodontic landmark used in establishing the width of the face.

Inferior Third.—In the inferior third of the face, the cheeks have a soft, rounded contour because of the subcutaneous fat and the buccal fat pad. The disappearance of this fat and the loss of the elasticity of connective tissue is responsible for the hollow cheeks seen in the aged. This sunken appearance of the cheeks can, in turn, exaggerate the prominence of the zygomatic region, thus effecting a rather radical change in the facial contour (Fig. 3, *B*).

If the posterior teeth are lost and not properly replaced, the unsupported cheeks tend to collapse and move medially to meet the laterally expanding tongue (Fig. 4). This is an example of Nature attempting to fulfill the law of an unnatural space.

Extending beyond the base of the nose to the labiomental sulcus is the region of the lips (Fig. 1). Both the maxillary and mandibular lips are greatly variable in contour, size, and shape and are very mobile. The lips normally approximate each other lightly when the mandible is in physiologic rest position. Their true anatomic shape and size can best be seen in this position. The lips are joined to each other

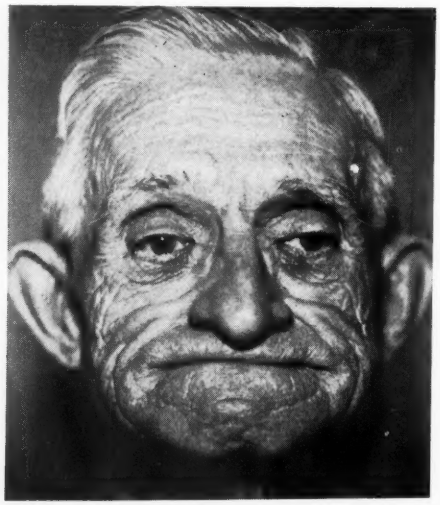

Fig. 4.—A patient of geriatric age reflecting normal aging changes.

by a delicate connecting fold at the corner of the mouth. This area, the angularis oris, is readily affected by malnutrition, loss of support, obesity, and aging processes. The adjustable shape in the angularis oris expresses varied emotions. This fold, when depressed, results in a "down in the mouth" expression, but it portrays a different emotion if the corners of the mouth are turned upward, as in smiling or laughter (Fig. 6).

The red area or vermilion border of the lips is described by Orban[4] as "the transitional zone between the skin covering the outer surface of the lip and the true mucous membrane lining the inner surface."

In the midline of the red zone of the maxillary lip is a slight projection called the tubercle. The vertical groove connecting this area to the septum of the nose is the philtrum, which is bounded on both sides by a ridge. The anatomic integrity of the philtrum is lost either when it is not supported by the anterior maxillary teeth and alveolar ridge or when it is distorted by overextension of dentures.

A. *B.*

Fig. 5.—Two views of the same patient. *A*, The face in repose. *B*, Anatomy in action or the "vitality factor."

Below the tubercle, in the middle of the mandibular lip, is a small indentation. From this area, the red zone of the lip widens and then narrows to the corners of the mouth. The mandibular lip is usually longer and more flexible than the maxillary lip.

The lips, highly expressive features of the face, are the "curtain to the mouth." Together with the mouth, they constitute an organ unique in that it plays a dual role in man's ability to convey his thoughts and emotions through both speech and facial expressions. This is the area in which the dentist performs his specialty. His treatment to maintain or replace its structures is of necessity concerned with all vital functions performed by this organ.

The fissure between the lips is the opening to the oral cavity. Usually, the gross movements of the lips are associated with opening and closing the oral fissure by depression or elevation of the mandible. The more delicate lip movements of facial expression and speech can be made even though the mandible may be stabilized by occlusion of the teeth or by holding a pipe. The dynamic movements of the

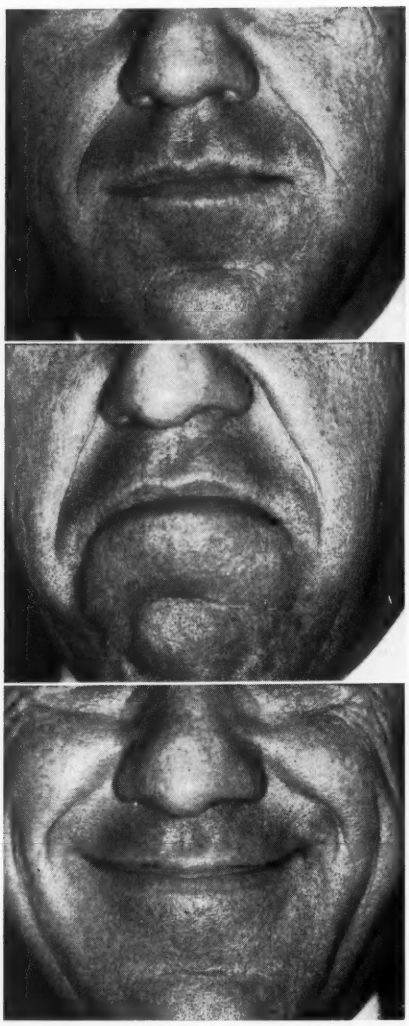

Fig. 6.—Three views of the lip and cheek regions of the same person showing attitudes of the lips. *A*, In repose. *B*, Downcast. *C*, Smiling.

lips in speech vary between individuals, reflecting racial as well as national characteristics. These movements of the lips may change in individuals when the supporting structures are missing or altered, when sickness occurs, and in advancing age.

One of the features that exerts a major influence on facial contours and profile is the eminence of the chin, a strictly human characteristic. Its degree of prominence determines whether it provides a strong or weak element to the general facial contour. However, loss of teeth and protrusion of the mandible may increase the prominence of the chin in older people. In middle life, there may be numerous layers of fat producing the "double chin." This reflects a general contour noted in infants,

whose facial features are less clearly demarcated from neck contours than is found in youth, where the sharp delineations of both areas are strongly defined.

NECK

The neck, a columnar structure connecting the head with the trunk, varies in length and thickness. It reflects variations according to sex in its prominences, and its differing curvatures influence the postural contours. Strong musculature development in this area may provide additional contour changes. The neck area also reveals tensions of the individual, and aging changes may be noted when tonicity has been lost and folds and wrinkled or crepelike skin of old age develop (Fig. 7).

Various expressive movements of the head, such as nodding to indicate concurrence, shaking to express disagreement, or tilting to imply a questioning attitude, are made possible by muscular contraction. Therefore, the neck serves both as the originator of characteristic movements which convey feeling and as the structural housing for the voice mechanism and parts of the respiratory and digestive tracts.

The neck area serves as an aid in prosthetic diagnosis. It is a critical region in evaluating the success of an oral prosthesis because of the changes evoked in it when teeth are lost and the tonicity of the neck musculature is decreased. These result in signs of increased stress.

SUMMARY

Thus far, external signs and symptoms as revealed in facial features and contours have been considered. These diagnostic aids are readily visible to the dentist as he first sees his patient. But as the patient begins to relax and speak, the dentist has an opportunity to observe the fleeting facial movements and mannerisms characteristic of that individual. He is watching what has been termed the fourth dimension, the vitality factor, or anatomy in action. This will be considered in subsequent articles of this series.

Fig. 7.—A patient of geriatric age showing aging changes and tension in the neck region.

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COMPLETE DENTURES

FACTORS INFLUENCING SATISFACTION WITH COMPLETE DENTURES IN GERIATRIC PATIENTS

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DENTISTS CONSIDER dentures successful when they meet certain technologic standards. However, patients evaluate dentures from the point of view of their own satisfaction. The ability of the patient to use the dentures for mastication or speech, considerations of esthetics, psychologic factors, and the attitude of the patient all influence his ability to adjust to, accept, and even manipulate the dentures. Thus, the satisfaction of the patient is a strong determinant of success in complete denture service.

The purpose of this investigation was to analyze the relative importance of a number of individual factors that constitute the basis for satisfactory oral conditions and satisfactory technical procedures. These factors determine a good denture as far as the dentist is concerned. Two of the three members of the team were selected to analyze these factors because of their long experience with complete denture construction. The third member analyzed the psychologic factors which might determine the satisfaction of the patient with his dentures. He assessed a number of psychologic factors (personality of the patient, relation to dentist, intelligence, etc.) in relation to the satisfaction of the patient. He was aided in this analysis by a clinical psychologist who had worked with and was familiar with the patients. All pooled their data to determine the relative degree to which the various psychologic, functional, technical, and oral factors were associated with satisfaction of the patient with the dentures.

This report deals with the effects of various clinical factors in determining the satisfaction of geriatric patients with their dentures. A more detailed presentation of the relation of psychologic, technical, and biologic factors to the satisfaction of the patients and dentists will be available in subsequent reports.

This article won the Grabow Prize granted by the Tel Aviv Branch of the Israeli Dental Association for original research during 1960.

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TABLE I. SATISFACTION WITH COMPLETE DENTURES IN 127 MEN AND WOMEN

SEX	PATIENT'S SATISFACTION WITH DENTURES						TOTAL	
	SATISFIED		SATISFIED BUT HAS OBJECTIONS		DISSATISFIED			
	NO.	PER CENT	NO.	PER CENT	NO.	PER CENT	NO.	PER CENT
Men	28	68	9	22	4	10	41	100
Women	60	70	15	18	11	12	86	100
Total	88	69	24	19	15	12	127	100

TABLE II. RELATION BETWEEN PATIENT'S SATISFACTION WITH COMPLETE DENTURES AND TYPE OF POSTERIOR TEETH (DURING THE FIRST YEAR OF USE)

TYPE OF POSTERIOR TEETH	PATIENT'S SATISFACTION WITH DENTURES						TOTAL	
	SATISFIED		SATISFIED BUT HAS OBJECTIONS		DISSATISFIED			
	NO.	PER CENT	NO.	PER CENT	NO.	PER CENT	NO.	PER CENT
Porcelain	33	62	14	26.5	6	11.5	53	100
Acrylic resin	55	74.5	10	13.5	9	12	74	100
Total	88	69	24	19	15	12	127	100

TABLE III. RELATION BETWEEN PATIENT'S REPORT ON MASTICATORY FUNCTION AND SATISFACTION WITH COMPLETE DENTURES

MASTICATORY FUNCTION	PATIENT'S SATISFACTION WITH DENTURES			TOTAL
	SATISFIED	SATISFIED BUT HAS OBJECTIONS	DISSATISFIED	
Efficient	75	1	0	76
Fair	13	19	3	35
Inefficient	0	4	12	16
Total	88	24	15	127

C = 0.704; maximum coefficient = 0.816.

METHODS AND MATERIALS

The subjects consisted of geriatric patients living in four old age homes in Israel. The group was selected because of homogeneity of age and ethnic origin and availability for controlled study. The group consisted of 127 men and women 61 to 86 years of age living under the same good physical and psychologic conditions.

A homogeneous group of geriatric patients with the same cultural and social background was chosen to keep individual variables at a minimum. The patients were treated by four dentists, each one in charge of a separate home. They received their new complete dentures and were observed in periods ranging from 3 months to 1 year. This group was composed of two-thirds women and one-third men (Table I). Dentists treating these patients did not know that the patients would be evaluated later.

TABLE IV. PATIENT'S REPORT ON COMFORT OF COMPLETE DENTURES RELATED TO GENERAL SATISFACTION WITH THEM

PATIENT'S REPORT ON COMFORT OF DENTURES	PATIENT'S SATISFACTION WITH DENTURES			TOTAL
	SATISFIED	SATISFIED BUT HAS OBJECTIONS	DISSATISFIED	
Comfortable	81	14	2	97
Fair	5	9	2	16
Uncomfortable	2	1	11	14
Total	88	24	15	127

C = 0.637; maximum coefficient = 0.816.

METHODS OF COMPLETE DENTURE CONSTRUCTION

Four dentists participated in the construction of the dentures. Their experience in geriodontics ranged from 2 years (one dentist) to 7 years (three dentists). All received special technical training under the supervision of the chief dentist of this organization. All used the same procedures during the clinical phases of complete denture construction, including the use of the face-bow and adjustable articulators. By standardization of all methods of work, technical variables were kept at a minimum. Acrylic resin posterior teeth were used for 74 patients and porcelain posterior teeth for 53 patients.

COLLECTION OF DATA

Two trained prosthodontists made all clinical and oral examinations and evaluated all dentures without the knowledge of the dentists or of who the dentists were.

TABLE V. PATIENT'S REPORT ON MASTICATORY FUNCTION RELATED TO PERFORMANCE IN PEANUT TEST

PATIENT'S REPORT	SATISFACTORY IN TEST	AVERAGE IN TEST	UNSATISFACTORY IN TEST	TOTAL
Satisfactory in mastication	12	50	14	76
Fair in mastication	7	15	13	35
Unsatisfactory in mastication	1	8	7	16
Total	20	73	34	127

C = 0.255; maximum coefficient = 0.816.

One of the examiners, aided by another dentist and an assistant, conducted the chewing tests with peanuts.

The satisfaction of the patient with his dentures and the patient's report as to masticatory function were determined by another dentist trained in the field of psychology who had the help of a professional psychologist. These data were collected by interviewing each patient over a period of approximately ½ hour. The data were not available to the clinical examiners until the study was completed. The specific methods and results obtained by this interview and the relation of satisfaction with dentures to various psychologic factors within the patient and patient-dentist interaction will be reported separately.

STATISTICAL ANALYSIS

The coefficient of association (C) between different factors was calculated by the method suggested by Arkin and Colton.[1] This coefficient of association (the coefficient of mean-square contingency) is based on a comparison of the number of cases actually occurring in a given cell or box and the number of cases which would occur in the cell due to chance. A perfect relationship is 0.816 when (as in our test) a 3 by 3 table classification is used.

All findings and conclusions from this study relate only to this specific group of geriatric patients. These patients lived in a closed, institutional society, received treatment free of charge, and had no choice in the selection of their dentist.

SATISFACTION WITH DENTURES IN MEN AND WOMEN

It is generally accepted that sex differences exist in the ability of patients to adapt to complete dentures. This is especially evident in women at the menopause and during the postmenopausal period.[2] In this group of patients, more women complained about the appearance of their dentures, while more men had objections regarding mastication. However, statistical evaluation of satisfaction and dissatisfaction showed no significant differences between men and women, indicating that both sexes reacted similarly toward their complete dentures (Table I).

The general satisfaction with dentures was high (Table I). This finding is in accord with the report of a survey of institutionalized patients in an old age home by Ruskin and Leeds.[3] They reported that 20 of 23 patients used their lower and upper dentures although some patients removed the lower dentures when eating. Almost 87 per cent were more or less satisfied with their dentures. In this group, 88 per cent were more or less satisfied. Five times as many patients expressed objections or dissatisfaction with lower than with upper dentures.[4]

SATISFACTION WITH POSTERIOR TOOTH MATERIAL

In these patients, it did not matter whether porcelain or acrylic resin posterior teeth were used (Table II). However, patient satisfaction was recorded within the first year of use while the resin teeth still had basically unaltered occlusal patterns. A survey by Koerner[5] on acrylic resin teeth after 3 to 7 years of clinical use indicated that the occlusal pattern was ground to flat surfaces.

SATISFACTION WITH DENTURES AND MASTICATORY FUNCTION

An almost perfect relation existed between patient satisfaction with the dentures and the patient report on masticatory function (Table III). C equaled 0.704 and came close to the theoretic maximum coefficient of 0.816.

The comfort in using the dentures in speaking and in all other activities besides eating was also highly correlated with patient satisfaction (C = 0.637) but was not as highly associated as was chewing (Table IV).

PATIENT'S CHEWING ABILITY AS COMPARED WITH THE PEANUT TEST

The significance and the reliability of the peanut masticatory test have been discussed by many authors.[6-8] We used the weight test with fresh-roasted peanuts for assessing masticatory performance. The patients chewed 5 Gm. of roasted pea-

TABLE VI. CORRELATION BETWEEN PATIENT'S SATISFACTION WITH COMPLETE DENTURES AND CLINICAL FIT OF DENTURES AS EVALUATED BY EXAMINERS

EVALUATION OF DENTURES BY EXAMINERS	PATIENT'S SATISFACTION WITH DENTURES			TOTAL
	SATISFIED	SATISFIED BUT HAS OBJECTIONS	DISSATISFIED	
Good	41	13	4	58
Fair	41	10	10	61
Poor	6	1	1	8
Total	88	24	15	127

C = 0.155; maximum coefficient = 0.816.

TABLE VII. SATISFACTION WITH COMPLETE DENTURES AS RELATED TO SOCIAL ADJUSTMENT OF THE PATIENT

SOCIAL ADJUSTMENT OF PATIENT	PATIENT'S SATISFACTION WITH DENTURES			TOTAL
	SATISFIED	SATISFIED BUT HAS OBJECTIONS	DISSATISFIED	
Well adjusted	54	15	4	73
Variable	26	6	7	39
Disturbed, not adjusted	8	3	4	15
Total	88	24	15	127

C = 0.239; maximum coefficient = 0.816.

TABLE VIII. COMPARISON BETWEEN PATIENT'S REPORT ON DENTIST'S ATTITUDE TOWARD HIM AND DENTIST'S REPORT ON PATIENT'S COOPERATION DURING TREATMENT

DENTIST'S REPORT ON PATIENT'S COOPERATION	PATIENT'S REPORT ON DENTIST'S ATTITUDE			TOTAL
	POSITIVE	INDIFFERENT	NEGATIVE	
Cooperative	84	30	2	116
Indifferent	5	4	0	9
Negative	1	1	0	2
Total	90	35	2	127

C = 0.127; maximum coefficient = 0.816.

nuts using forty masticatory strokes. The resulting bolus was passed through a 100 mesh per square inch sieve, and the remainder was dried and reweighed.

The amount of peanuts which passed through the screen was used to determine the performance. The scoring was unsatisfactory when less than 15 per cent passed through the sieve, average when 15 to 35 per cent passed through the sieve, and satisfactory when more than 35 per cent passed through the sieve.

Trapozzano[6] used several techniques for testing the efficiency of different occlusal patterns. He states: "The accuracy of this technique [the peanut test] is questionable, although the same inherent difficulty may be expected to occur, regardless of the type of food utilized for a test bolus." McLean[7] agreed with Swenson as to the reliability of data obtained by having patients chew: ". . . Such tests were not of any value because the patient could not be relied upon to chew with the same vigor, speed, and force throughout all the tests."

Payne[8] felt that the use of a screen mesh for testing of tooth efficiency is scientific with regard to the food that passes through the mesh but does not take into consideration that which is left behind. In his opinion, uniformity of particle size throughout the entire bolus is more important in digestion than the amount of pulverized food passing through the screen.

Our tests (Table V) show that the relation between the peanut test and the patient's report on his masticatory ability was weak ($C = 0.255$). Thus, the peanut test shows only the ability of the patient to chew peanuts under controlled conditions and does not necessarily reflect his ability to masticate a wide variety of different foods. It is a conscious act which does not give a clear indication as to how the patient uses the teeth in daily living.

PATIENT SATISFACTION AND CLINICAL FIT OF THE DENTURES

The clinical fit of the dentures as evaluated by the dentists showed a weak relation to patient satisfaction ($C = 0.155$) and, by implication, a weak correlation with the ability to use them (Table VI). Therefore, there was almost no correlation between the patient's appraisal of his own dentures and the dentist's appraisal of the same dentures. Apparently, the patients could manage their dentures whether or not stability, retention, and other factors involved in denture construction were present. Young[9] estimated that improper centric relation existed in about 90 per cent of complete dentures when anatomic tooth forms were used. McKevitt[10] estimated that $2,500,000 is invested in denture adhesive powders in the United States. This is a clear indication of substandard performance and conditions. Still, most people adjust to their dentures. A subsequent report will deal with the factors of denture construction and their relation to patient satisfaction.

SOCIAL ADJUSTMENT AND PATIENT SATISFACTION WITH DENTURES

Personal adjustment is the process by which the individual seeks to satisfy his drives and innate and acquired needs in the physical and cultural environment in which he finds himself. The well-adjusted person is able to satisfy his needs quickly and adequately within the controls and outlets provided by his culture. This ability to adjust is related to the social organization of society.[11]

The social adjustment of each patient was determined by a questionnaire composed by a psychologist experienced in the field of geriatrics. The questionnaires were filled out by the director of the home or by the house mother, depending on which was better acquainted with the patient. The answers took into consideration the patient's participation in community life and activities and his social adjustment to his roommates. Evaluation of these factors and of his complaints, realistic or otherwise, placed the patient into one of three groups: (1) well adjusted, (2) variable, or (3) socially negative (disturbed adjustment).

Analysis of social adjustment showed that 73 patients were well adjusted, 39 patients were variable, and 15 patients were disturbed (Table VII). The relation between social adjustment and satisfaction with dentures was present but weak

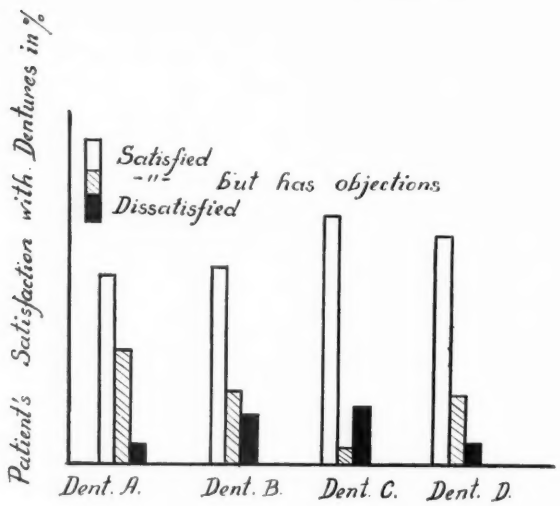

Fig. 1.

(C = 0.239). This finding was surprising because social adjustment has been suggested as an important factor in the critical period of adjustment to new dentures.[12] However, it may be that social adjustment is different in an institutionalized population of old people.

All patients showed normal motivation for social and health reasons except 4 patients who displayed a narrow motivation and 2 who demonstrated no motivation at all.

Among the 4 residents who displayed a narrow motivation, 1 was highly satisfied, 1 was dissatisfied, and 2 were satisfied and used their dentures but had objections. Both badly motivated patients used their dentures, one with complaints

TABLE IX. PATIENT'S SATISFACTION WITH DENTURES AS RELATED TO THE TREATING DENTIST

PATIENT'S SATISFACTION WITH DENTURES	TREATING DENTISTS							
	A		B		C		D	
	NO.	PER CENT	NO.	PER CENT	NO.	PER CENT	NO.	PER CENT
Satisfied	10	59	16	61.5	30	77	32	71
Satisfied but has objections	6	35	6	23	2	5	10	22
Dissatisfied	1	6	4	15.5	7	18	3	7
Total	17	100	26	100	39	100	45	100

Between dentists A and C, Q = 0.4; maximum = 1.

TABLE X. CLINICAL FIT OF DENTURES (AS EVALUATED BY EXAMINERS) RELATED TO TREATING DENTISTS

FIT OF DENTURES	TREATING DENTISTS							
	A		B		C		D	
	NO.	PER CENT	NO.	PER CENT	NO.	PER CENT	NO.	PER CENT
Good	6	35	16	61.5	12	30	24	53
Fair	10	60	10	38.5	25	64	19	42
Poor	1	5	0	0	2	6	2	5
Total	17	100	26	100	39	100	45	100

Between dentists B and C, Q = 0.57; maximum = 1.

and the other fully satisfied. On the other hand, 13 out of the group of 15 dissatisfied patients fell in the group of well-motivated patients.

PATIENT'S REPORT ON THE DENTIST AND DENTIST'S REPORT ON THE PATIENT

In the specific conditions of life in a social, philanthropic institution, the patient's cooperation may be influenced by his reaction to his dentist and the appreciation of his helpfulness, kindness, and understanding. Surprisingly enough, there was a weak correlation between patient cooperation as seen by the dentist and the dentist's attitude as seen by the patient (Table VIII). Most patients who were pleased with the dentist's attitude were seen as positive personalities by the den-

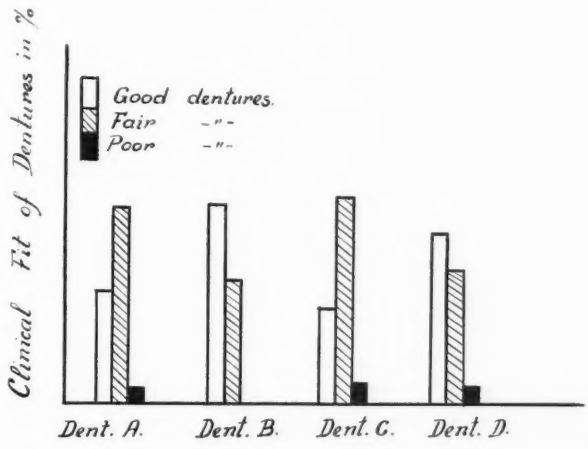

Fig. 2.

tist (84 patients). No patient and no dentist regarded themselves as mutually negative. However, two dentists reported 2 patients as negative, and 2 other patients reported the dentists as negative. Thirty patients saw their dentists as indifferent, while the dentists saw these same patients as positive. Only 6 patients evaluated their dentist's attitude as better than the respective dentists evaluated theirs. These data suggest that the four dentists showed greater tolerance toward their patients than the patients showed toward them.

The lack of correlation results from an evaluation of two subjective personal opinions of two different personalities. The correlation would be more conclusive if the dentist's attitude and the patient's cooperation were assessed by a third, objective person.

PATIENT SATISFACTION AS RELATED TO THE DENTIST

It is a widely accepted fact that there is a definite correlation between the dentist's personality and his professional skills in determining the patient's satisfaction with his complete dentures. The percentage of satisfied patients differed among the several dentists from 59 to 77 per cent (Table IX). The personality of the dentists seemed to influence the patient's satisfaction (Fig. 1).

The distribution of satisfied and of satisfied but with objections was different for every treating dentist (Table IX). In the Q test,[1] $Q = 0.4$ in comparing the differences in satisfaction with dentures made by dentists A and C. These dentists showed the widest contrast, whereas dentists B and D show similar results. However, the low Q value of 0.4 as compared to a maximum of 1 indicates that these differences may have been due to chance and not necessarily to differences in dentists. Since the number of patients differed widely from dentist to dentist, a difference of 1 or 2 satisfied or dissatisfied patients greatly influenced the picture. An increase of patients in this survey could have smoothed the differences.

On the other hand, dentist C, who had the highest percentage of satisfied patients (77 per cent), had also the highest percentage of dissatified patients (18 per cent) and was the only woman dentist in this group. Her warm approach to patients may explain the higher percentage of success. However, she was the only dentist who had difficulty in speaking with patients because she had no common language with most of them and had a different background. These factors may have influenced the higher percentage of dissatisfied patients.

CLINICAL FIT AND TREATING DENTISTS

The number of poorly fitting dentures ranged from zero to 6 per cent and may be regarded as low (Table X). The principal differences appear only in the figures indicating dentures that fit well and fair (Fig. 2). However, no good method of objectively evaluating dentures was discovered. The border between average-fitting and well-fitting dentures was ill defined. The result of the Q test between dentists B and C equaled 0.57. This indicates that the difference between the dentists with the most widely varying results may be due to chance despite the fact that dentist B produced relatively twice as many good dentures (61.5 per cent) as dentist C (30 per cent).

DISCUSSION

The complete satisfaction of both patients and dentists in evaluating dentures is a necessary condition for success in complete denture construction. Whenever the patient and the dentist are both dissatisfied with the respective evaluation, such dentures may be regarded as failures. When one party is satisfied (patient *or* dentist) and the other is not, the dentures fall somewhere between the two categories.

The methods used for the clinical evaluation of dentures in this project were not exact. Pleasure* and many others have pointed out that there is no exact method available for this purpose. Boucher[13] presents a list of unanswered questions related to prosthodontics. This list shows that most clinical problems related to complete dentures are still open questions. Only when the dental profession can answer these questions will there be sure means to analyze and evaluate the clinical fit of complete dentures. We related the fit of the dentures to all of the supporting structures in the mouth and to the activities of related organs, but still we were not able to avoid bias and misinterpretation in our examinations.

Trapozzano[14] studied similar problems in 12 denture patients. He found that the chewing efficiency was higher with balanced occlusion than with unbalanced occlusion, but only in two instances was it decisively clear. The patient's preference was independent of the type of occlusion or the ability to chew. Neither occlusion produced a greater degree of soreness than the other. Payne,[15] in discussing these findings, stated: "There is danger that the student or young dentist might be tempted, on the basis of this investigation, to feel that 'anything goes,' that only 'fanatics' balance occlusion." He stated further: "On the basis of this investigation and others we have found that the patient's estimation of his own chewing efficiency is not always valid. Patients are individuals. Most of them can and will adapt to complete dentures on the basis of satisfaction with appearance and confidence in their dentists. Certainly, *accuracy* will not hinder their adaptation."

Our findings, also, present a potential danger of misinterpretation or generalization. A high standard of complete denture performance is an indispensable part of success. In evaluating the results of this survey, it must be remembered that the subjects received treatment on a philanthropic basis and had no choice of the dentist. In the general population, the social motivation is strong. The effort connected with the relatively high cost of dentures proves the urgent need for a social adjustment. In these institutions, new dentures can be secured with relatively little effort. However, the unsuitable attitude of a dentist giving a treatment free of charge may be an important factor for these persons.

The emotional reaction of aged persons is determined by subjective factors, while the ability to make objective judgment diminishes with progressive senescence. Therefore, the patient's satisfaction may often be an expression of his general feeling of elation or gratification toward a dentist or an institution that gives him normal life conditions. Landa[16] stated that the attitude of the patient frequently determines success or failure regardless of the care and ability of the dentist.

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*M. A. Pleasure: Personal communication.

No single factor seemed to determine the patient's satisfaction with complete dentures. Rather, the interplay of different psychologic, biologic, anatomic, and constructional factors determined this satisfaction. The presence, combination, and intensity of most psychologic and biologic factors cannot be foreseen before the end of the period of adjustment to complete dentures. Therefore, these factors should be regarded as open questions which can be instrumental sometimes in improving the chance of success of the dentures and sometimes in destroying it. The anatomic and constructional problems can be appreciated to some extent during the treatment and insertion of dentures.

SUMMARY AND CONCLUSIONS

A homogeneous group of geriatric patients with the same cultural and social background was checked during a period of from 3 to 12 months after insertion of dentures.

A statistical analysis of the findings indicates:

1. Eighty-eight patients (69 per cent) were satisfied and fully used their dentures, 24 patients (19 per cent) were satisfied but had some minor objections, and 15 patients (12 per cent) were dissatisfied.

2. Patient satisfaction with complete dentures was closely related to the successful use of the lower denture.

3. There was no significant difference between men and women in the appraisal of complete dentures.

4. The two types of posterior teeth (porcelain and acrylic resin) had no significant influence on patient satisfaction in the first year.

5. An almost perfect relationship was found between satisfaction with dentures and the patient's report on his chewing efficiency. A high correlation was found between the patient's satisfaction and his comfort in using the dentures in speaking, working, leisure time, and other activities.

6. Chewing tests did not reflect the real ability to masticate a wide variety of different foods.

7. Almost no correlation was found between the clinical fit of the dentures and the patient satisfaction.

8. The influence of social adjustment was present, but the correlation with the patient satisfaction was surprisingly weak.

9. The patient's opinion of the dentist and the dentist's appraisal of patient cooperation were not correlated.

10. Some evidence indicated that satisfaction of the patient might be related to the personality and ability of the dentist. However, the data did not reliably support this relationship.

This study was initiated and supported by the late Boris Pliskin, M.D., former Medical Director of Malben-JDC in Israel, whose great efforts in geriatric-gerodontic medicine will never be forgotten and whom we wish to commemorate by this work.

We wish to express our deepest appreciation and thanks to Dr. M. Massler, University of Illinois, College of Dentistry, for his assistance and guidance in understanding the problems discussed in our articles and for his help in the evaluation of the study, to which he devoted a great deal of time and effort during his stay in our country.

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We wish to express our thanks to the management and staff of the Department for Care of the Aged of Malben-JDC and to our dentists, technicians, assistants, and office personnel for their selfless participation and help.

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COMPLETE DENTURE STABILITY RELATED TO TOOTH POSITION

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A CONSTANT OBJECTIVE of dentists engaged in the field of prosthodontics is to obtain optimal retention and stability of complete dentures. A review of dental history and modern practice reveals that countless physical and lesser physiologic means have been employed in attempting to gain this end. A representative list of these means would include the use of expanding springs, suction cups, post dams and border dams, relief chambers, weighted bases, denture adhesives, static impressions, balanced occlusion, reverse occlusal curves, modified tooth forms, altered tooth positions, repelling magnets, attracting magnets, denture implants, and impressions to relieve, compress, or place tissues.

The investigation reported here was prompted by the diverse views which prevail regarding the influence of tooth position on denture stability. The strong advocates of altered tooth positions feel that the posterior teeth should be placed so that occlusal loads are concentrated on or lingual to the crest of the ridge. They contend that forces imparted in this manner tend to seat rather than tilt the dentures during function. They point to the crest of the ridge as the line around which rotation or tilting of the denture occurs.

In contrast, those who believe that the denture teeth should occupy the same position as the natural teeth in the denture space minimize the importance of placing the teeth on the ridge crest and consider the buccal slopes of the ridges as favorable areas to support the denture. Many of the latter group look to balanced occlusion to augment the stability of the dentures during mastication. The claims which both of the groups have generously documented appear to be based on observation and clinical experience, since a review of the literature fails to reveal reports of substantiating research investigations.

EXPERIMENTAL DESIGN

Through the use of sectional dentures and electronic strain gauges, the magnitude of the forces delivered to six areas of the maxillary tissues during mastication was determined. These areas were in the buccal flange, ridge crest, and palatal slope of each side, on a line projected through the first molars (Fig. 1). Recordings were made for comparison of the pressure applied to the supporting tissues by

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The opinions or assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

Read before the Academy of Denture Prosthetics in Minneapolis, Minn.

*Commanding Officer, U. S. Naval Dental School, National Naval Medical Center.

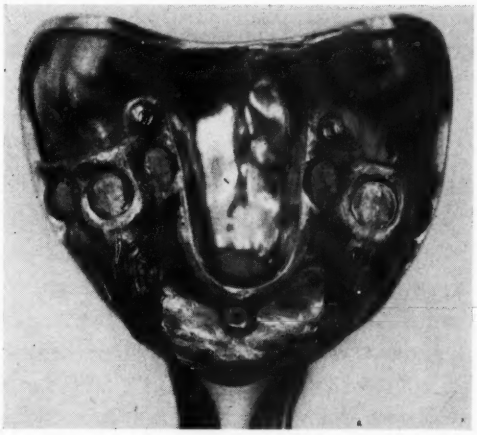

Fig. 1.—The maxillary metal base showing SR-4 type strain gauges attached to six pressure-recording areas.

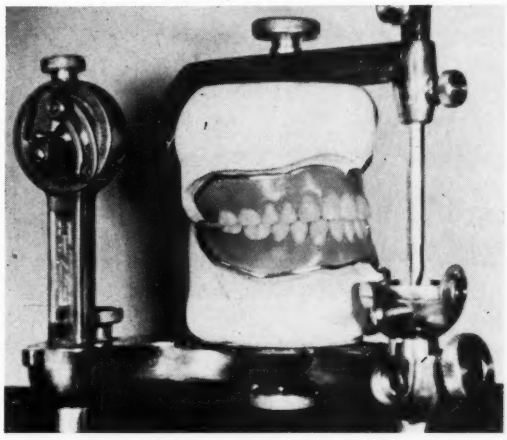

Fig. 2.—The assembled dentures with 20 degree posterior teeth in normal occlusal relation.

the maxillary dentures with posterior teeth arranged in both normal and crossbite relations. Details regarding fabrication of the test dentures and use of the electronic equipment have been reported previously.[1,2]

Denture sections, which carried 20 degree posterior teeth, were attached first to the cast metal bases (Fig. 2). All of the teeth were set in normal relations and were oriented, as nearly as could be determined, in the positions previously occupied by the natural teeth. In these positions, the mandibular posterior teeth and maxillary first bicuspids were directly in line with the respective residual ridges. However, the maxillary molars and second bicuspids were outside the crest of the residual maxillary ridge. The teeth were carefully balanced in lateral and protrusive excursions on a Hanau articulator which had been adjusted to the patient's condylar paths and to a flat incisal guidance.

Jumbo salted peanuts in 3 Gm. portions were chewed thirty strokes for each recording. This procedure was followed to produce five records of bilateral chewing and was repeated for unilateral chewing on both the left and right sides. The entire procedure was carried out on 3 consecutive days to produce a total of fifteen recordings of each type of chewing with the teeth in normal relations.

Upon completion of the recordings with the teeth in the "normal" positions, the metal bases and denture sections were returned to the articulator for modification of the occlusion.

The molars and second bicuspids were removed from the maxillary denture and replaced by new teeth in crossbite relation to their mandibular opponents (Fig. 3). When this rearrangement was completed, all of the posterior teeth of both dentures occupied positions directly in line with the crests of the ridges. The mandibular teeth were not altered, but the occlusal surfaces of the maxillary posterior teeth were adjusted to create a well-balanced occlusion.

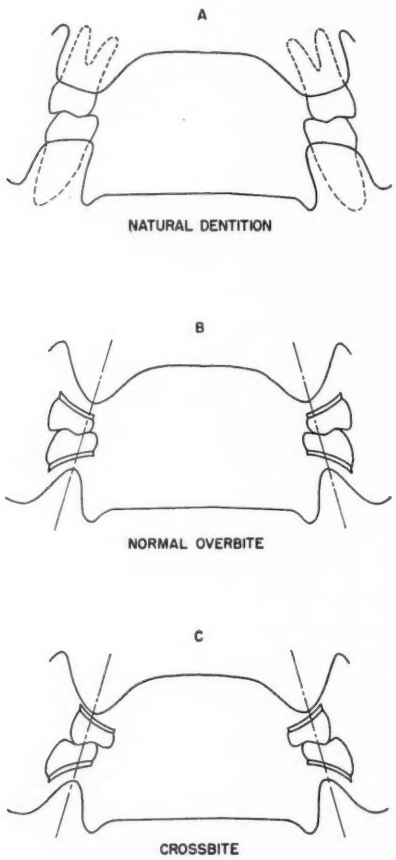

Fig. 3.—*A*, Schematic illustration of tooth positions in a natural dentition with normal vertical overlap. *B*, Artificial teeth set in the same position as the natural teeth. The maxillary molars are centered outside of the midline of the maxillary ridge. *C*, Repositioned maxillary molars in crossbite relationship centered in the midline of the maxillary ridge.

Chewing and recording procedures identical to those which had been carried out with the teeth in normal relation were repeated on 3 consecutive days with the posterior teeth in crossbite relation to produce records of unilateral and bilateral chewing.

OBSERVATIONS FROM RECORDINGS

Bilateral Chewing (Fig. 4).—

A: There was very little difference in the pressures recorded with the teeth in normal and in crossbite relations. The most notable difference was that the maxillary crossbite denture exerted 10 per cent more pressure on the right ridge crest and 4 per cent less pressure on the left ridge crest than did the normal relation denture.

B: Positive pressure was registered during 100 per cent of the chewing strokes in three areas of the normal relation denture and in five areas of the crossbite denture. The greatest variation was at the buccal flanges. With the crossbite denture, there were 14 per cent more positive pressure recordings from the right buccal flange and 63 per cent more from the left buccal flange than with the normal relation denture.

Unilateral Chewing on Left Side (Fig. 5).—

A: In general, the crossbite denture exerted greater pressure on the left side and less on the right side than did the normal relation denture. This was most noticeable at the ridge crest. In comparison with the normal relation denture, the crossbite denture exerted 22 per cent more pressure at the left ridge crest and 42 per cent less pressure at the right ridge crest.

B: In two areas, positive pressures were recorded during practically 100 per cent of the chewing strokes with both of the maxillary dentures. In four of the six recorded areas, the crossbite denture exerted positive pressure during an equal or greater number of chewing strokes than did the normal relation denture. However, at the right ridge crest, positive pressure was recorded during 16 per cent fewer chewing strokes with the crossbite denture than with the normal relation denture.

Unilateral Chewing on Right Side (Fig. 6).—

A: The greatest difference was noted at the left ridge crest, where the crossbite denture exerted 37 per cent less pressure than did the normal relation denture.

B: In comparison with the normal relation denture, the crossbite denture recorded positive pressure during an equal number of chewing strokes in three areas and a lesser number in two areas. The number of positive pressure recordings from the left buccal flange was negligible with each denture.

DISCUSSION

It was assumed that any improvement in denture stability that might be gained by centering the maxillary teeth over the crest of the ridge or lingually to it would be indicated by an increase in the number of positive pressure recordings and/or a decrease in the number of negative responses from the balancing side of the denture, provided the masticatory forces were within a comparable range. On the basis

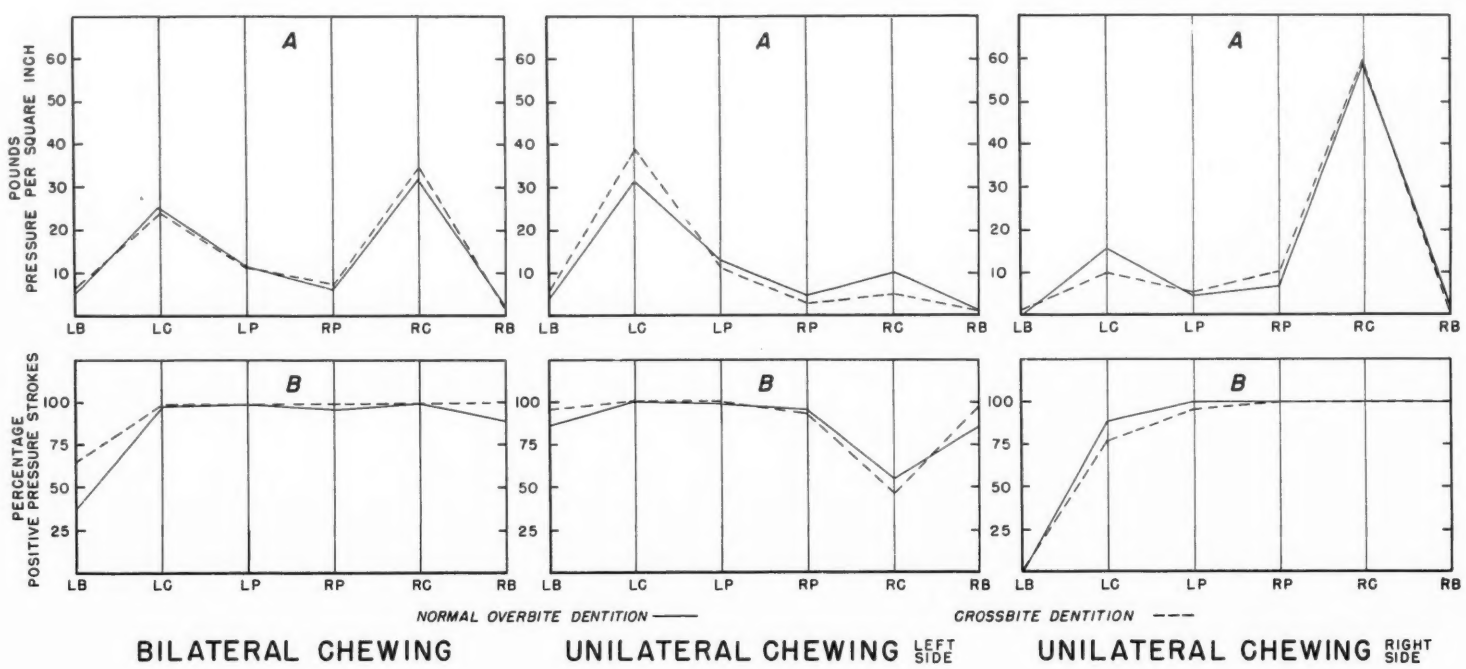

Fig. 4. Fig. 5. Fig. 6.

Fig. 4.—*A*, Distribution of pressure of six localized areas of the maxillary tissues during bilateral chewing. *B*, Positive pressure was recorded during almost 100 per cent of the chewing strokes in all areas except the left buccal. *(LB)* Left buccal area; *(LC)* left ridge crest area; *(LP)* left palatal area; *(RP)* right palatal area; *(RC)* right ridge crest area; *(RB)* right buccal area.

Fig. 5.—*A*, As compared with bilateral chewing, pressure at the left ridge crest increased approximately 30 per cent during unilateral chewing on the left side. Pressure on the nonworking side dropped to less than 25 per cent. *B*, As compared with bilateral chewing, the percentage of positive pressure strokes increased markedly in the left buccal area but decreased markedly at the ridge crest of the right side.

Fig. 6.—*A*, During unilateral chewing on the right side, pressure at the right ridge crest increased by approximately 200 per cent, as compared with bilateral chewing. At the same time, pressure on the nonworking side dropped to about 50 per cent. *B*, As compared with bilateral chewing, slight increases in the percentage of positive pressure strokes occurred at the right buccal flange and right palate during unilateral chewing on the right side. At the same time, the percentage decreased markedly at the buccal flange and ridge crest of the left side.

of this premise, the data did not provide evidence that the altered tooth positions augmented the stability of the maxillary denture.

The most outstanding observation from the recordings from both maxillary dentures was that denture stability and force distribution were more favorable during bilateral chewing than during unilateral chewing on either side. It was found with each denture that pressures at the ridge crest of the working side increased 30 to 80 per cent during unilateral chewing. There was an accompanying decrease in the number of positive pressure strokes on the balancing side during unilateral chewing on either side. This emphasizes again the importance of bilateral chewing as a means of augmenting the stability of complete dentures.

SUMMARY

Sectional dentures with electronic strain gauges attached were used as a means of evaluating the influence of posterior tooth position on the stability of a maxillary denture. The teeth were first arranged in normal relation for a series of chewing tests. The posterior teeth were then repositioned in crossbite relation for repetition of the tests.

It could not be determined from this test that denture stability was improved by placing the posterior teeth in crossbite relation; many similar tests will be required before conclusions can be drawn.

I wish to acknowledge indebtedness to J. C. Thompson, F. D. Carpenter, J. L. Eitel, and others of the U. S. Navy Electronics Laboratory, San Diego, for their counsel and technical assistance in this study, and to enlisted personnel of the U. S. Naval Training Center, San Diego, for compiling data and assisting in other phases of the work.

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INFLUENCE OF THE SUBLINGUAL FOLD ON RETENTION OF COMPLETE LOWER DENTURES

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THE RETENTION of a complete lower denture poses a problem that has taxed the ingenuity of dentists. The correct position for the denture border is easily determined in the labial, buccal, and posterior regions, but the exact placement of the denture border in the anterior lingual region has never been clearly explained.

The entire border of the denture should be in contact with soft, displaceable tissue to obtain the most satisfactory retention. However, the anterior lingual border of the lower denture is related to mucosa which moves under the influence of adjacent muscles. Consequently, the mucosa moves out of contact with the denture border. Herein lies one of the main problems of the retention of the lower denture.

The purpose of this article is to illustrate how the sublingual folds can be used to help maintain a seal in the anterior lingual region.

ANTERIOR LINGUAL REGION

The anterior lingual border of the denture should be extended to the floor of the mouth, but this level is continually altered during tongue movement. The floor of the mouth is normally at its lowest level when the tongue is lying in its resting position (Fig. 1). If the denture border is extended to contact the mucosa when the tongue is in this position, a satisfactory seal can be developed. However, when the floor of the mouth is raised, a pressure is exerted through the mucosa against the denture border which results either in ulceration of the epithelium in contact with the denture border or in the upward displacement of the denture. Therefore, the denture border cannot be extended below the highest level to which the mucosa is raised (Fig. 2). If the denture border is ended at this highest level, contact is lost when the mucosa drops to a lower level (Fig. 3), and retention will also be lost.

STRUCTURES RAISING THE FLOOR OF THE MOUTH

The tissues in the floor of the mouth are muscle and mucous membrane which are separated from each other by loose connective tissue containing glandular elements.

The most superiorly placed muscle is the genioglossus muscle, which is attached anteriorly to the superior genian tubercle and runs posteriorly to be attached into and become part of the tongue. This muscle is fan shaped, with its

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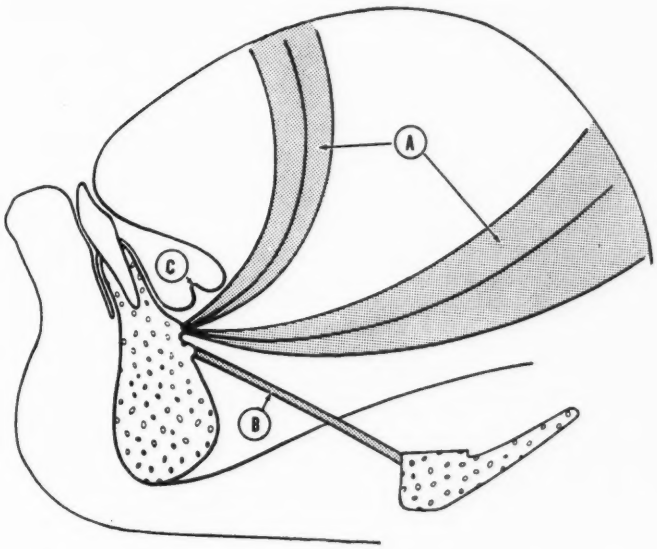

Fig. 1.—The distribution of tissues and the position of the floor of the mouth when the tongue is at rest: *(A)* the genioglossus muscle; *(B)* the geniohyoid muscle; *(C)* the sublingual fold.

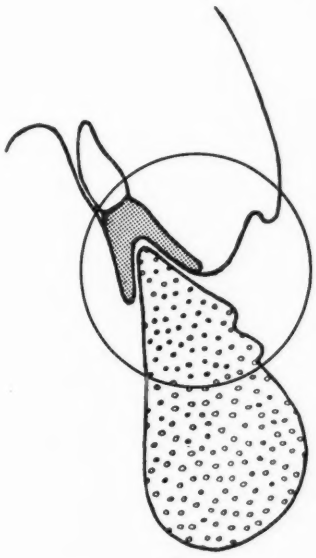

Fig. 2.

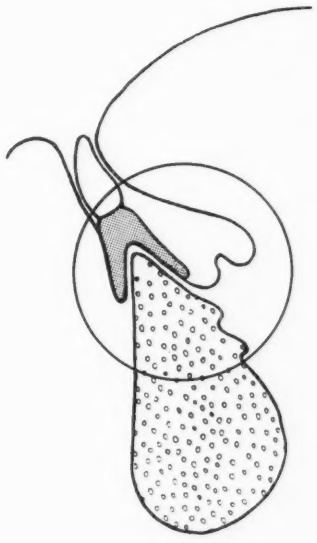

Fig. 3.

Fig. 2.—The lowest level to which the lingual border of the denture can be extended is determined by the highest level of the mucosa of the floor of the mouth.

Fig. 3.—When the tongue is relaxed, the floor of the mouth is lowered out of contact with the edge of the denture.

fibers radiating backward and upward to be inserted into the whole length of the body of the tongue.

Functionally, the genioglossus muscle consists of two parts. The posterior

group of fibers is attached into the posterior part of the tongue. The anterior group is attached just below the upper surface of the tongue at the junction of its anterior third with the middle third.

The posterior group of fibers protrudes the tongue by pulling on its posterior part and thus moving the entire structure forward. The fibers of the anterior group are relaxed during this process, and they, together with the surrounding tissues, are moved forward passively under the influence of pressure from the more posteriorly placed group of fibers.

Contraction of the superiorly placed anterior group of fibers of the genioglossus muscle depresses that part of the surface of the tongue which is a short distance posterior to the tip. This produces a marked concavity of that surface and tends to retract the tip of the tongue, causing it to move upward and backward.

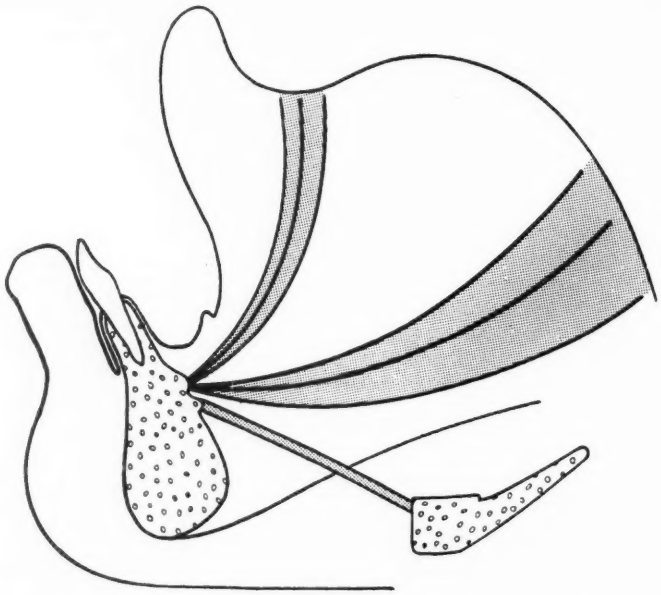

Fig. 4.—The position of the floor of the mouth when the tip of the tongue is retracted.

This movement occurs during the formation of the bolus and in the first stage of swallowing and actively raises the floor of the mouth to its highest level (Fig. 4). During these functions, the fibers of the anterior group are contracted strongly and, being superficially placed in the floor of the mouth, exert a strong pressure through the overlying mucosa against a denture base which might be obstructing its movement.

SUBLINGUAL FOLDS

Two folds in the mucosa overlying the genioglossus muscle run obliquely forward and inward at a varying distance from the alveolar ridge and nearly meet in

Fig. 5.—The sublingual folds overlie the genioglossus muscle.

the midline (Fig. 5). These are the left and right sublingual folds which carry the ducts of the corresponding submandibular salivary glands in their free borders. Some sublingual folds are quite small and others much larger (Figs. 6 and 7).

When the tip of the tongue is raised, the sublingual folds are also raised and are pulled away from the alveolar ridge (Fig. 4). When the tongue is relaxed and its tip is allowed to rest in contact with the lingual surfaces of the lower anterior teeth, the sublingual folds also move downward and forward nearer to the alveolar ridge and the denture border (Fig. 1).

Fig. 6.—Some sublingual folds are quite large.

APPLICATION OF THE ANATOMY OF THE FLOOR OF THE MOUTH

Friedman[1] describes the molding of the anterior lingual border of the impression in rather indefinite terms by stating: ". . . In the midline, it [the tracing compound] is extended posteriorly about 4 or 5 mm., tapering away to nothing in the premolar regions." Various tongue movements are advocated, but no definite indication is given as to what one should seek to achieve or of why to achieve it. Lewis[2,3] stresses the importance of what he calls the sublingual space between the alveolar ridge and the sublingual folds but gives no indication of how it may be utilized.

The factor actually governing the position of the anterior lingual border of the lower complete denture is the sublingual fold. The denture border cannot be extended below the highest level of the mucosa in this region. However, the

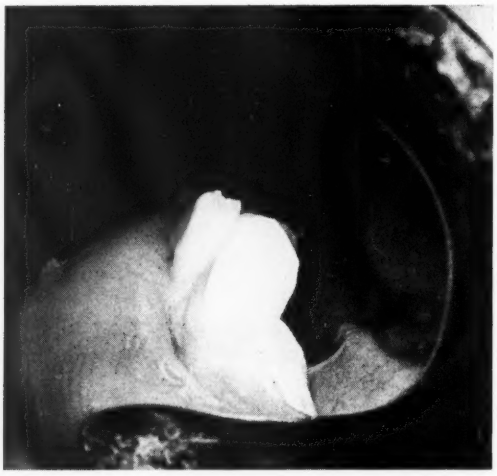

Fig. 7.—The sublingual folds in profile view.

border can be extended horizontally backward until contact is made with the sublingual fold. Thus, the seal is developed by the floor of the mouth when the tongue tip is retracted and by the sublingual fold when the tongue is relaxed in a forward position.

PROCEDURE

One way to achieve the correct form of the anterior lingual denture border is to extend the denture base (or special tray) downward with stick modeling compound while the tongue is retracted (Fig. 8). This achieves the correct degree of downward extension, and great care should be taken to avoid any further alteration in this direction.

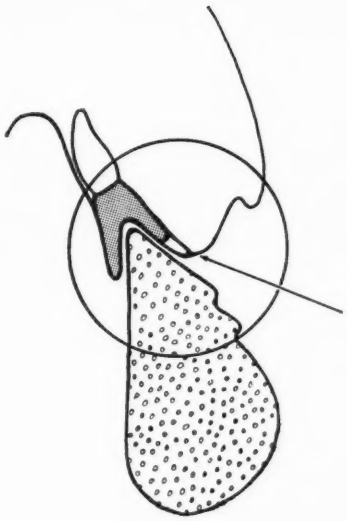

Fig. 8.

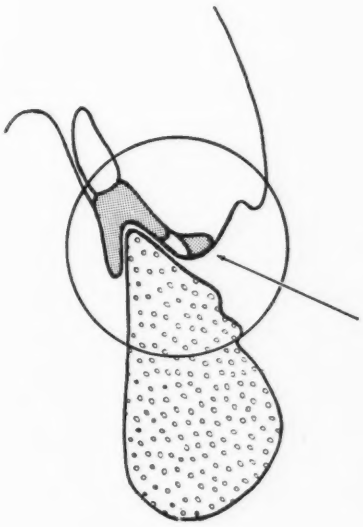

Fig. 9.

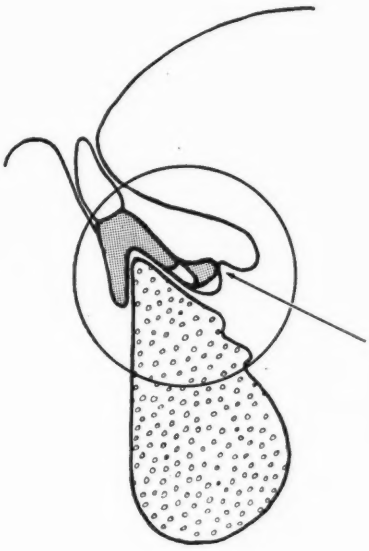

Fig. 10.

Fig. 8.—The denture base is extended down to contact the floor of the mouth while the tip of the tongue is retracted.

Fig. 9.—The border is extended backward while the tip of the tongue is retracted.

Fig. 10.—Contact is maintained by the sublingual fold when the tongue relaxes and the floor of the mouth drops down.

Then the border is extended backward with the tongue retracted (Fig. 9). This backward extension is frequently in a slightly upward direction as determined by the raising of the subjacent mucosa.

The posterior border of this extension is trimmed until the sublingual fold just makes contact with the border when the tongue is relaxed (Fig. 10). The edge of the posterior border is softened slightly and molded carefully by having the patient gently touch the red margin of the lower lip with the tip of the tongue. This movement presses the sublingual fold gently against the softened modeling compound.

The impression is completed by covering the modeling compound with a thin layer of zinc oxide–eugenol impression paste. The patient repeats both of the suggested tongue movements to maintain the correct downward and backward extensions of the anterior lingual border. In the final position, there will be contact between the denture border and the mucosa of the floor of the mouth in both of the extreme positions of the tongue.

CONCLUSIONS

The size and position of sublingual folds vary considerably in different patients. Some are large and well developed, whereas others are much smaller, particularly in elderly patients in whom degenerative changes have occurred. The smaller the fold, the poorer are the chances of complete success and the greater becomes the care required to achieve the necessary contact with the mucosa of the floor of the mouth.

I wish to express my appreciation to Mr. J. H. Lee, Head of the Department of Prosthetic Dentistry, Institute of Dental Surgery, for his valuable help and advice and to Mr. M. Potter of the Photographic Department for his assistance in preparing the illustrations.

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RELATIONSHIP OF VARIOUS SKULL REFERENCE LINES

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THE CONDYLE PATH INCLINATION must be determined in relation to the cranial plane or a line of reference.[1] For example, the average condyle path inclinations as given by Gysi[2,3] were measured in relation to his prosthetic plane. These values cannot be compared directly to the inclinations measured in relation to the Frankfort plane or its near equivalent, the axis-orbital plane, which is used in mounting casts on the Dentatus articulator, the Hanau model H-2 series, and the McCollum, Stuart, and Granger instruments.

In order to compare condyle path inclinations as measured in relation to various planes, the average angle between these planes, especially in their projections on the sagittal plane, should be determined. Actually, the present measurements are of lines rather than planes because the three dimensionality of the planes is projected in two dimensions as lines on a sagittal roentgenogram.

Björk[4] indicated the angular relationship between various reference lines of the skull. He also determined the error of angular measurements for twenty double determinations. Björk used the occlusal "line," the Frankfort "line," and the nasion-sella line and also drew a line from the anterior nasal spine to the porion point. This line does not differ much from the Camper plane. The angles between these planes, or lines, can be calculated from Björk's measurements.

Gysi[2] defines the prosthetic plane as a line connecting the lower border of the auditory meatus with the ala nasi. In 18 edentulous patients, he found a mean condyle path inclination of 31 degrees for the right and left sides. He later determined the condyle path inclination of another 216 edentulous subjects to average 33 degrees for both sides.[3]

AIM OF INVESTIGATION

The average angles were measured between three reference lines used in prosthetics and the nasion-sella line, which is used in orthodontic cephalometric analysis. It is possible to transpose approximate angulations from one reference line to another when these average angles are known.

DEFINITIONS

Björk[5] defined certain measuring points: the nasion *(n)*, sella turcica *(s)*, incision superius *(is)*, superior occlusal line *(OL_s)*, and orbitale *(or)* (Fig. 1).

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The porion, an anthropologic point, is the midpoint of the upper edge of the external auditory meatus.[5] In this investigation, a tangent to the upper part of the ring indicator in the middle of the ear posts was used as the porion and as the posterior point of the Camper line. The anterior indicator of this line is the lower edge of the ala nasi. Actually, Camper[6] never mentioned any special part of the ear opening to decide his plane.

Several reference lines (Fig. 1) were used in this investigation: (1) *NSL*, the nasion-sella line, (2) the line from the orbitale *(or)* to the porion point, which is the Frankfort line (this line does not coincide with the line of the anthropologic Frankfort plane), (3) the tangent to the ala nasi and to the upper edge of the ring indicator (porion point), which comprises the Camper line, and (4) OL_s, the maxillary occlusal line (through the incision superius [*is*] and the distobuccal cusp of the upper first molar or the upper second molar when the former was missing).

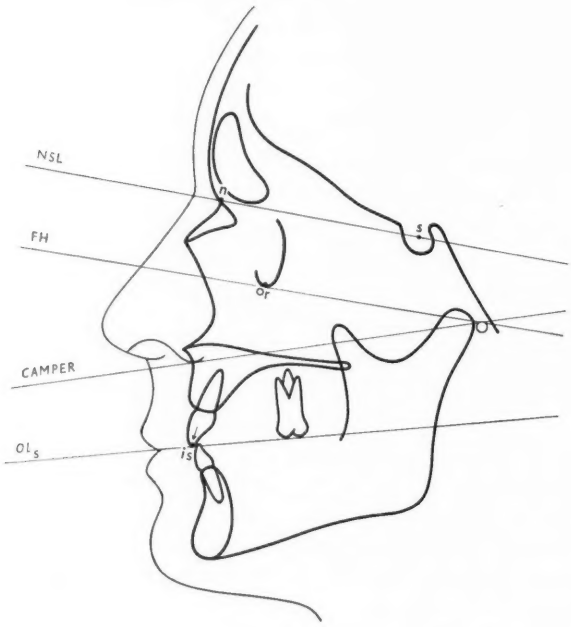

Fig. 1.—Cephalometric roentgenographic tracing with the measuring points and reference lines.

MATERIAL AND METHODS

Cephalometric roentgenograms were made of 97 male dental students, ages 20 to 22 years. The subjects each had no more than two missing premolars or molars, not counting third molars. To qualify as subjects, they could have missing only one tooth in each quadrant and only one permanent first molar.

Cephalometric roentgenograms of only 87 subjects were used because it was impossible to determine the location of the ring indicator for 10.

The ala nasi was painted with a radiopaque substance (tantalum powder with glycerin) before the exposure, to make it easier to locate. The cephalostat described by Sonesson[7] was used.

CONSTRUCTION OF REFERENCE LINES

Transparent paper was placed over each cephalogram, and the reference lines were drawn in the following order: (1) nasion-sella line, (2) orbitale–porion point line, (3) maxillary occlusal line, and (4) Camper line. A point between the two contours was chosen when a double projection was found.

These lines were constructed for the complete series, and the angles were measured. The sequence of the cephalograms was altered, new reference lines were drawn, and the measurements were repeated to reduce the error as much as possible. The entire series of double determinations was completed in a 2 month period.

The angles that open anteriorly were designated as plus and those that open posteriorly were indicated as minus. It was necessary to transpose some of the lines to obtain and determine angles.

RESULTS

The results of the angular determinations of the 87 subjects appear in Table I. A ranking of the various angles was carried out according to the magnitude of the standard deviation. The angles with the smallest rank always crossed each other when drawn on the tracing paper. The average angles formed by the reference lines are shown in Fig. 1.

Gysi[2] considered his prosthetic plane to be parallel to the occlusal plane. He placed the posterior part of the reference line definitely lower than the actual construction of the Camper plane. This may account for the angular difference of almost 7 degrees between the occlusal plane and the Camper plane.

There is a difference of 11 degrees between the Frankfort plane and the prosthetic plane of Gysi, which roughly coincides with the occlusal plane of this series. Table II gives a comparison of some mean values of condyle path inclinations of various investigators.

The materials from which these inclinations have been derived vary in age, type of dentitions, etc. Therefore, the inclinations could not be compared within 1 to 2 degrees. Also, the posterior reference position is not the same in all reports. Nevakari[8] and Lindblom[9] use the occlusal (intercuspal) position, while the other authors use the retruded position.

TABLE I. MEANS, STANDARD DEVIATION OF MEANS OF ANGLES OF REFERENCE LINES, AND RANK FIGURES OF STANDARD DEVIATIONS

ANGLE	MEAN	S.D.	RANK
*FH** —Camper line	17.1	2.8	1
OL_s —Camper line	−6.7	3.6	2
NSL—OL_s	14.6	4.1	3
NSL—*FH**	4.2	4.4	4
OL_s —*FH**	10.7	5.0	5

*Constructed with the special porion point used in this investigation.

TABLE II. COMPARISON OF VARIOUS MEAN VALUES OF CONDYLE PATH INCLINATIONS IN RELATION TO VARIOUS SKULL REFERENCE LINES

AUTHOR (YEAR)	NO. OF CASES	MEAN VALUES (IN DEGREES) OF CONDYLE PATH INCLINATION TO VARIOUS REFERENCE LINES*			
		OCCLUSAL PLANE	FRANKFORT LINE	CAMPER LINE	NASION-SELLA LINE
Gysi[2] (1929)	18	*31*	42	24	46
Gysi[3] (1958)	219	*33*	44	26	48
Nevakari[8] (1958)	40	34	*45*	28	49
Isaacson[10] (1959)	36	25	*36*	29	40
Lindblom[9] (1960)	18	40	50	*33*	54
Posselt and Nevstedt[11] (1961)	101	29	*40*	23	44

*The original reference lines to which degrees were indicated are italicized.

DISCUSSION

The standard deviations of the angles of this investigation are considerably larger than those found by Koski and Virolainen[12] (Table I). These relatively large variations are probably due to three facts in the tracing and measuring procedures: (1) the difficulty of deciding the different reference points, (2) the error in transposing the lines for measuring the angles, and (3) the error in measuring the angles.

Another group of factors influencing the ranking of exactness with which the angles can be determined consists of biologic factors such as growth, variability of anatomy, etc. The latter group of errors is entirely outside the scope of this article. Only the first sources of error are considered.

Björk[4] stated that marking the orbitale points in cephalometric roentgenograms causes a rather large error. Actually, the Frankfort plane enters into the first, fourth, and fifth ranks. The Frankfort line must be always transposed, and this procedure involves a relatively large error.

The porion point is difficult to reproduce exactly from one time to another because the external auditory meatus has considerable resiliency. In spite of this difficulty with regard to the Camper line (a difficulty which also exists in the construction of the Frankfort line), it exhibited a relatively small standard deviation; this may have been because it never required transposition.

The distobuccal cusp of the upper first molar of the occlusal plane was difficult and sometimes impossible to locate. The mesiobuccal cusp of the second molar was used when the distobuccal cusp of the first molar could not be found.

The angular values compare reasonably well with those of Björk.[4]

SUMMARY

Cephalometric roentgenograms from 87 male dental students were analyzed. The nasion-sella line, the Frankfort line, the Camper line, and the occlusal line of the maxilla were marked on tracing paper. The average angles between these lines were calculated, and the angles were ranked according to the magnitude of the variation.

Measurements of condyle path inclinations in relation to some reference lines can be roughly "translated" with regard to other reference lines by means of these average angular values. It is also possible to compare the indications of mean value condyle path inclinations with those of other investigations.

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SEATING THE CONDYLES FOR CENTRIC RELATION RECORDS

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CENTRIC RELATION is not always easy to record even though the dentist knows what is needed and the patient understands the problem and is attempting to cooperate. The proper seating of the condyles for equilibration or for making an interocclusal centric relation record can be a frustrating experience.

The fact that the patient can make rotary movements of the mandible does not ensure that the condyles are seated in the most posterior and superior positions in the fossae. Closure into a wax wafer which is softened in the posterior region and firm in the anterior region is not adequate for proper seating of the condyles for many patients.

This article describes a procedure for seating the condyles in their centric positions either for visual examination of deflective occlusal contacts or for mounting diagnostic casts on the articulator.

PROCEDURE

The patient is taught to arc the mandible as near to hinge closure as possible. When the patient understands what is expected of him, a quarter segment of modeling compound* is doubled for thickness and placed on the lingual incisal aspects of the upper anterior teeth. The dentist cradles the point of the patient's chin with the thumb and forefinger of the right hand to detect a protrusive movement combined with the hinge closure. At no time should the mandible be pushed in a posterior direction. The mandible should be moved by the patient and not worked up and down by the dentist.

The patient makes repeated closures little by little into the modeling compound until the teeth that would contact first are about 1/16 inch apart. The modeling compound is removed, cooled, and replaced between the teeth. The modeling compound should not extend distally to the cuspids.

Then the patient repeatedly clenches the teeth on the modeling compound, which acts as a positive stop, without opening the mouth. The dentist places his finger tips over the masseter muscles and tells the patient to contract these muscles when he clenches them. If the muscles become tired or temporary discomfort develops, the patient may rest with the modeling compound between the teeth, resuming the clenching and relaxing after a brief pause. If the patient has had a centric occlusion in an eccentric relation, he will soon become aware of wanting to close the jaw posteriorly to the record made in the modeling compound, and another piece of modeling compound is softened and the procedure repeated.

*Kerr's Red Compound.

One or two changes of modeling compound may be needed if the existing occlusion is not close to the centric relation. A period of exercise ranging from 1 to 5 minutes permits vertical and posterior seating of the condyles not usually accomplished in a single attempt.

LOCATING DEFLECTIVE CONTACTS IN NATURAL TEETH

The clenching exercises are completed, and the modeling compound index is removed. If saliva has accumulated, the patient must not bring the teeth together when he expectorates. The dentist again places his thumb and forefinger on the chin, and the patient is asked to open and close the jaw in an arc of about ½ inch without permitting any teeth to contact. After the patient has made several smooth rotary movements, he is asked to close the jaw a little further each time until he feels the slightest "feather touch" between the upper and lower teeth.

In most instances, the ligament system of the mandible has been stretched, and the muscles will not hold the condyle against the articulating eminence for more than a few seconds. Therefore, the modeling compound index is replaced from time to time, and the patient clenches the teeth tightly against it two or three times. This procedure will keep the condyles seated.

Occasionally, patients with malocclusion and resulting neuromuscular confusion cannot cooperate in some of the simplest jaw movements. A few minutes of clenching the teeth on the modeling compound index helps to eliminate this neuromuscular confusion.

This conditioning procedure should be performed before the hinge axis is located. It is easier to record the hinge location if the muscles and joints have received this exercise.

MOUNTING CASTS ON THE ARTICULATOR

The modeling compound index made last is used as an anterior index for centric relation registration for mounting diagnostic casts or working casts or remounting finished restorations. A zinc oxide–eugenol cement* is mixed to a moderately firm consistency (2 Gm. of liquid to 5 Gm. of powder) and divided into two parts. The two parts of mixed cement are dabbed into cement powder to reduce the tackiness and are molded into two cylindric shapes about ¼ inch in diameter and ¾ inch long. The modeling compound index is removed, and the pieces of soft cement are placed over the molar and bicuspid teeth. The modeling compound index is replaced, and the patient is asked to close the mouth firmly and hold the jaw in that position until the cement is hard. The thickness of the interocclusal record is determined by the thickness of the modeling compound index.

The split-cast technique is used in mounting the upper cast on the articulator. It serves two purposes: (1) it permits an accurate check on the relation of the upper and lower casts as oriented by the first centric relation registration, and (2) it permits checking one centric relation registration against another. Three centric relation registrations should be made for each patient, and all should be iden-

*Ackerman.

tical. A new modeling compound index should be made for each centric relation registration.

The fine detail in the zinc oxide–eugenol cement record is removed when seating casts of natural or prepared teeth or when transferring full coverage castings. The occlusal surfaces of the restoration and the modeling compound index are lubricated lightly.

Similar modeling compound indices are made for the three eccentric positions when transfering jaw relations to an adjustable articulator. However, this procedure does not eliminate the need for remounting the completed restorations. Even though the occlusion appears to be perfect at the time of insertion, in most instances, a few days later, there will be deflective occlusal contacts in the second molar region. The adjustments are slight, and the need for more than one remounting has not been encountered.

SUMMARY

The mandible is held in suspension by a muscle and ligament system. In many people, the skull-mandible ligament system has been stretched vertically as a result of occlusal disharmony, and it is not until the muscles of mastication have started to work with force that the joints approach their normal relationships. A method of positioning the condyles in their most posterior and superior positions has been described.

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CIRCULAR ROTATIONS IN MANDIBULAR MOVEMENTS

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I HAVE DEMONSTRATED in previous articles that the movements of the mandible are elliptic.[1] "The movements of the mandible are a system of elliptical and circular curves correlated at the hinge axis. This correlation is established by means of an anterior stylus tracing (Gothic arch tracing)."[2]

Several circular rotational movements are also present in mandibular movements. This article deals with these movements.

MOVING POINTS OF THE MANDIBLE

The real geometric relation of the moving points of the mandible is represented by an imaginary line between the condyle and the lower incisors (Fig. 1). The tips of the cusps of the lower posterior teeth are represented by perpendicular lines from these points to the imaginary line (Fig. 2). Geometrically, the protrusive movement of the mandible is represented in Fig. 3. This is the true geometric relation of the cusps to the paths of the mandible regardless of the size and shape of the mandible or restoration to which the posterior teeth are attached.

The lateral movements of the mandible on a projection on the horizontal plane are represented in a similar manner (Fig. 4). The tips of the cusps are represented by points attached by lines perpendicular to those representing the mandible (Fig. 5).

In a three dimensional representation on a mandible, each of the cusps is geometrically attached to an imaginary triangular plane formed by lines from one condyle to the other and to the incisor point (Fig. 6). Guide line *L* represents the mandible along the mandibular paths (Fig. 7).

Point *1'* divides line *L* into two equal parts. The two halves of this line are radii of a circle in the rotational movement of line *L*. Therefore, point *1'* is making a circular rotation and at the same time point *1* is making a circular movement around point *1'*.

Points *2'* through *6'* divide line *L* in two parts of different length. Therefore, in the rotational movement of line *L*, each of the segments of this line becomes a semiaxis of an ellipse. Points *2'* through *6'* make elliptic movements (Fig. 8). Points *1* through *6* make elliptic movements but at the same time make a circular rotation around their corresponding numbers, *1'* through *6'*.

The same situation exists in the lateral movement (Fig. 9). The mandible is guided along the lateral condylar paths and the lateral incisal paths. If a cusp point

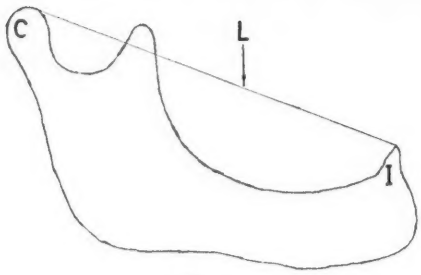

Fig. 1.

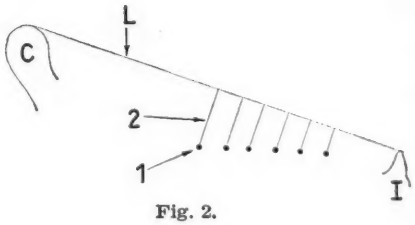

Fig. 2.

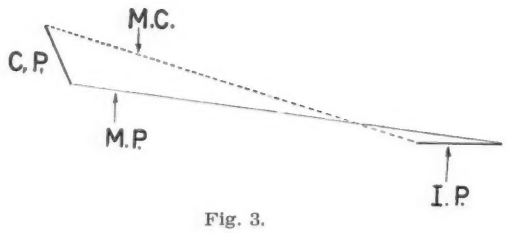

Fig. 3.

Fig. 1.—*L*, an imaginary line, joins the condyle *(C)* and the incisor *(I)*.

Fig. 2.—*L*, an imaginary line, joins the condyle *(C)* and the incisor *(I)*. Six points *(1)* represent the tips of the cusps of the posterior teeth, and perpendicular lines *(2)* extend from the points to line *L*.

Fig. 3.—A geometric representation of the protrusive movement of the mandible: *(C.P.)* the condylar path; *(I.P.)* the incisal path; *(M.C.)* the mandible in centric relation; *(M.P.)* the mandible in a protrusive position.

happens to be attached to the middle of the mandibular line, this point makes a circular movement. All other points make elliptic movements.

In the three dimensional aspect, as a result of the downward movement of the condyle on the balancing side, the path of point *1* forms a part of a circular helix and the paths of all other points form parts of elliptic helices.

CORRELATION OF THE ELLIPTIC AND CIRCULAR MOVEMENTS

The opening movement of the mandible is a circular rotational movement associated with a forward gliding movement of the condyle. We are only interested in the rotational movement from a prosthetic viewpoint. Therefore, this movement must be separated from the gliding movement and its center of rotation found.

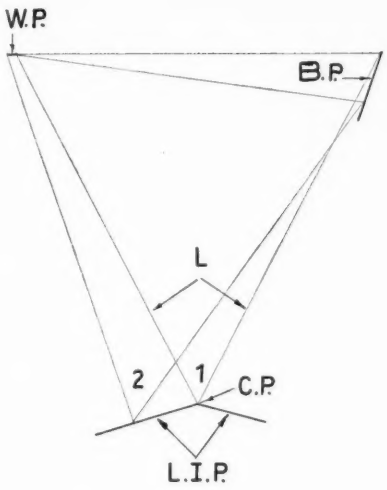

Fig. 4.

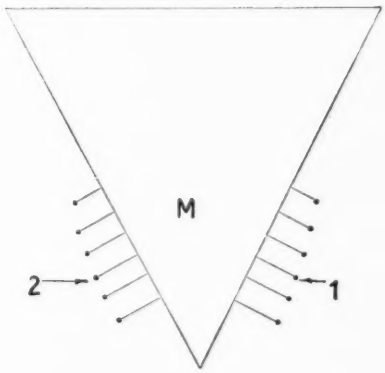

Fig. 5.

Fig. 4.—A lateral movement of the mandible: *(L)* lines representing the mandible; *(L.I.P.)* the lateral incisal path; *(B.P.)* the balancing path of the condyle; *(W.P.)* the working path of the condyle; *(C.P.)* the centric position; *(1)* the mandible in centric relation; *(2)* the mandible in a lateral position.

Fig. 5.—The points representing the cusps *(1* and *2)* are attached to the lines representing the mandible *(M)* by perpendicular lines.

The circular movement is correlated with elliptic movements of the mandible at this center of rotation or hinge axis. This correlation is established with the aid of an anterior needle point tracing that must be correctly obtained. The method of correctly obtaining the needle point tracing has been explained before.[3]

ESTABLISHING THE HINGE AXIS OF OPENING AND LATERAL MOVEMENTS

The correct height and direction of the occlusal plane are obtained, and the correct vertical dimension of occlusion is determined.

A table is fixed to the lower occlusion rim. The table contains a central bearing screw and a means to support the pointer that is used to locate the hinge axis.

A stylus is attached to the upper baseplate, and a metallic plate is positioned on the palate for contact of the central bearing screw.

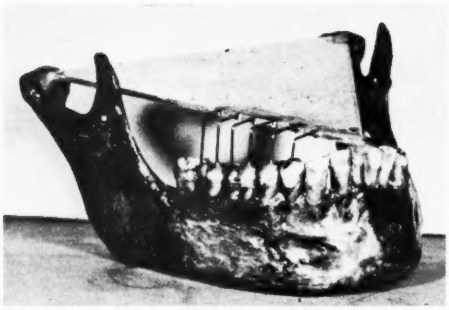

Fig. 6.—Some of the cusp points are attached by perpendicular lines to the triangle representing the mandible.

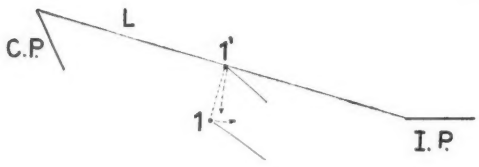

Fig. 7.

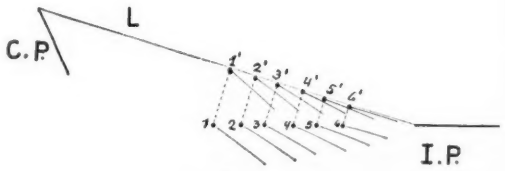

Fig. 8.

Fig. 7.—Point *1'* is located in the middle of line *L*. When the mandible moves along the condylar path *(C.P.)* and the incisal path *(I.P.)*, point *1'* makes a circular movement and at the same time a rotation around point *1'*, as shown by the arrows.

Fig. 8.—Points *1* through *6*, guided by line *L* along the condylar path *(C.P.)* and the incisal path *(I.P.)*, produce elliptic paths and at the same time make rotational movements around points *1'* through *6'*.

The location of the hinge axis is tentatively marked on the patient's face, the baseplates are placed in position, and the stylus is positioned perpendicularly to the hinge axis by means of a square (Fig. 10).

The patient is asked to make the necessary movements to produce the needle point tracing. The condylar pointer is placed in position and directed to the tentative mark of the hinge axis. A piece of polymerized methyl methacrylate resin 3/16 inch thick is interposed between the central bearing screw and the upper base, and the patient repeats the movements for the needle point tracing.

If the inclination of the stylus is correct, the needle point tracing at this increased vertical dimension will be exactly the same as at the correct vertical dimension because the stylus is placed as a tangent to the circular opening movement.

The centric position must be the same for both positions. If there is a discrepancy, the stylus is adjusted until the same tracing is obtained at both positions.

The condylar pointer should also be directed at the same point for both positions. The position of the pointer is adjusted until the desired result is obtained (Figs. 11 and 12).

In this manner, the correct relation of the hinge axis to the opening component and the lateral movements of the mandible is established. The procedure is simple, it requires little time, the equipment is uncomplicated and inexpensive, and no training of the patient is necessary.

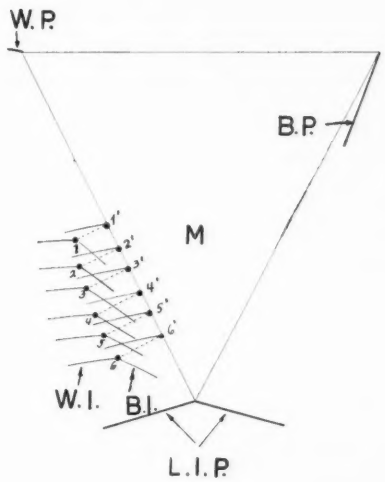

Fig. 9.—In a lateral movement represented on the horizontal plane, point *1'* makes a rotational movement. Points *2* through *6* make elliptic movements. Points *1* through *6* make elliptic movements but at the same time make rotational movements around points *1'* through *6' (L.I.P.)* The lateral incisal path; *(B.P.)* the balancing path; *(W.P.)* the working condylar path; *(W.I.)* the working cusp path; *(B.I.)* the balancing cusp path.

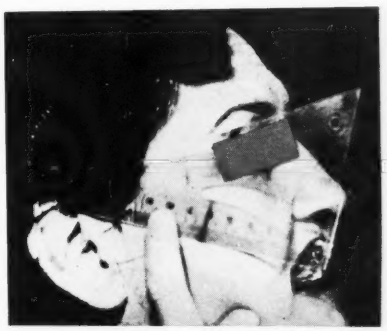

Fig. 10.—The stylus is placed perpendicularly to a line from the hinge axis to the point of the stylus by means of a square placed on the patient's face.

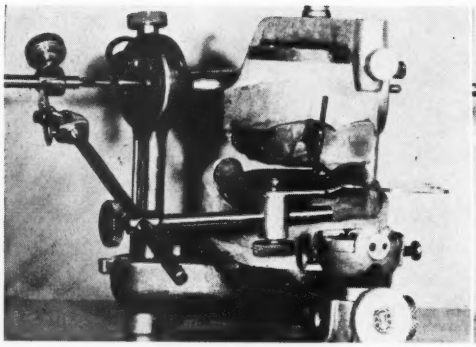

Fig. 11.

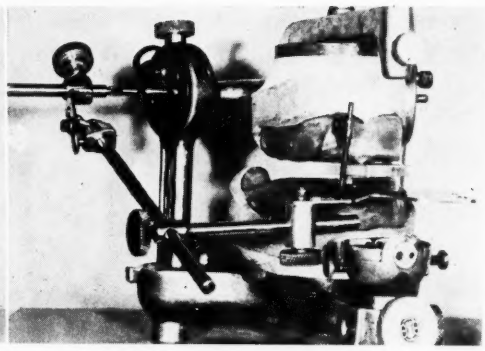

Fig. 12.

Fig. 11.—An articulator on which is represented the correct normal vertical relation. The condylar pointer is directed to the hinge axis, and the needle point tracing has been made.

Fig. 12.—A piece of polymerized methyl methacrylate resin is interposed between the central bearing screw and the upper baseplate. The needle point tracing and the location of the condylar pointer are the same for both positions.

SUMMARY

The geometric representation of the mandible and its movements are explained. A simple method of locating the hinge axis and correlating the circular opening movement and the lateral movements of the mandible has been described.

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1. Villa A., H.: Mathematical Interpretation of Mandibular Movements, J. Pros. Den. **8**:887-892, 1958.
2. Villa A., H.: A Technique for the Use of Nonanatomic Posterior Teeth, J. Pros. Den. To be published.
3. Villa A., H.: Gothic Arch Tracing, J. Pros. Den. **9**:624-628, 1959.

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HINGE AXIS LOCATION ON AN EXPERIMENTAL BASIS

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Seattle and Olympia, Wash.

THE IMPORTANCE OF LOCATING the transverse hinge was first expressed by Campion,[1] who emphasized that in mounting casts on an articulator, the axis of the articulator shaft should coincide with the mandibular transverse hinge axis of the patient. Brotman[2] has demonstrated this by mathematical means, showing that a precisely measurable error is introduced at the occlusal surfaces when the position of the articulator hinge does not coincide with the anatomic hinge. This error in closure is shown to increase proportionately as the deviation of the articulator hinge from the anatomic hinge increases. This emphasizes the need for accurate hinge axis location in order to reproduce accurate occlusal relationships on the articulator. Recognition of this principle has brought attention to the necessity for hinge axis location, and, among others, Granger[3] and McCollum[4] hold that a high degree of accuracy of location is obtainable.

Factors do exist, however, which make hinge axis location difficult and which have led to doubts that a precise point can be located with accuracy. The major problem involved is the rather limited opening and closing arc available in pure hinge motion which can be used in determining the axis location. Posselt,[5] in a study of 50 subjects, found the maximum separation of the incisal edges of the anterior teeth in hinge motion to vary from 19.2 to 25.6 mm. By applying these figures to Bonwill's triangle with its sagittal plane length of 87 mm., this measurement is translated into a 10 to 13 degree opening and closing arc available for use in hinge axis location.

Kurth and Feinstein[6] adapted a device for hinge axis location to a Hanau articulator which had been modified to open and close through only 10 degrees. In a series of experiments made in an effort to locate the axis of the articulator shaft, the results were such that the center of rotation was found to be within an area 2 mm. across. Because of this variation, they decided that hinge axis location can result in only an approximation and is of little value.

In a similar experiment, under carefully controlled experimental conditions utilizing a modified Hanau articulator, Borgh and Posselt[7] found the attainable accuracy in hinge axis location using a 10 degree arc of motion to be within an area 1.5 mm. in diameter.

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METHODS AND MATERIALS

Because of questions in our minds similar to those expressed by Boucher[8] as to possible inaccuracies in the armamentarium, we felt that a special instrument should be designed for this experimental study.

The resulting instrument consists primarily of a base and an upright member supporting a smaller horizontal table with a 5¼ inch horizontal arm which extends laterally between the base and the horizontal table. The outer end of this arm has an opening with a setscrew for a round vertical rod 4½ inches long. The hinge axis locator to be used is attached to this vertical rod (Fig. 1). The horizontal arm with its vertical rod and attached axis locator moves through an arc parallel with the base. Its movement is limited by setscrew stops placed in holes

Fig. 1.

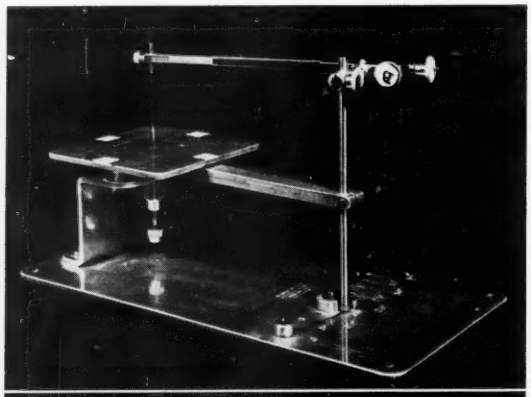

Fig. 2.

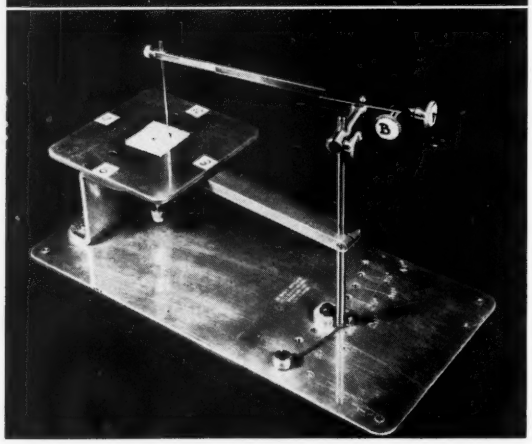

Fig. 1.—The experimental instrument with the axis locator attached.
Fig. 2.—The axis aperture is covered with graph paper. The aperture is marked for demonstration, and a 15 degree path of the axis locator pin has been inked in.

drilled in the base in 5 degree segments of an arc increasing to 40 degrees. If a limit of 10 degrees of motion for the axis locator is desired, the setscrew stop is

placed in the 10 degree opening. Thus, the horizontal arm with its attached hinge axis locator can move only within this limited range.

The central bearing portion of the horizontal arm around which it rotates was accurately center drilled, and within this bore rests a close-fitting axis needle which can be raised to extend through an aperture in the horizontal table. In this manner, the exact axis can be projected above the surface of the table.

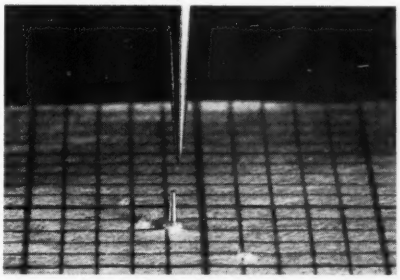

Fig. 3.—The axis pin has been raised through the graph paper on the table.

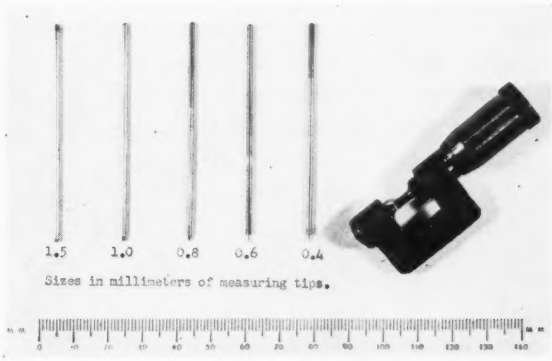

Fig. 4.—The measuring pins used to determine the distance of the location from the exact axis. The measurements indicated are the diameters of the areas of the tips.

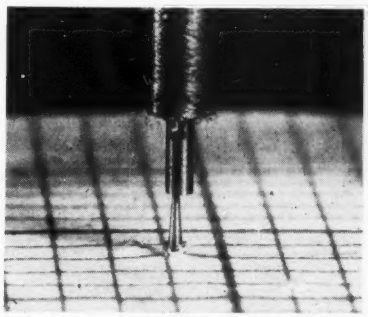

Fig. 5.—A 0.4 mm. diameter measuring pin covers the axis pin.

Prior to making a test for accuracy in locating the axis, the aperture and the axis needle are concealed by covering the central portion of the horizontal table with adhesive-backed, millimeter-ruled graph paper. The axis location is made by moving the arm through its arc and using the lines of the graph paper as a guide to judge movement of the locator pin (Fig. 2). Adjustments of the locator are made until no movement except rotation is observed. When the operator feels he has located the axis accurately, the supervisor of the experiment raises the axis needle through the aperture and forces it through the graph paper (Fig. 3).

The axis locator pin is carefully removed and replaced by one of a series of measuring pins. The ends of these pins were machined and measured by a micrometer at diameters of 0.4, 0.6, 0.8, 1, and 1.5 mm. (Fig. 4). If the smallest measuring tip of 0.4 mm. diameter covers the point of the axis needle, the location is considered to have been within 0.2 mm. from the axis (Fig. 5). If the measuring tip does not cover the point of the axis needle, successively larger tips are used until the one covering the axis needle point is found.

The measuring tip is then removed, the axis locator pin is replaced and offset, and the graph paper is removed and replaced to provide a fresh, unmarked area for the next trial.

A number of operators of varied backgrounds were tested, and five attempts at axis location were made by each person. The range of movement was varied from 5 to 15 degrees.

Accordingly, group I consisted of lay persons completely untrained and unfamiliar with these techniques (10 degrees of movement).

In group II were dentists who had seen hinge axis locations performed and who had at least slight experience with this technique (10 degrees of movement).

Group III consisted of members of a study club experienced in hinge axis location* (10 degrees of movement).

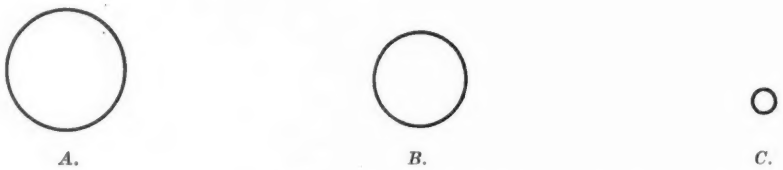

Fig. 6.—The relative sizes of the areas in which the points were located. *A*, Diameter 2 mm., area 3.1416 sq. mm. (Kurth and Feinstein). *B*, Diameter 1.5 mm., area 1.7671 sq. mm. (Borgh and Posselt). *C*, Diameter 0.4 mm., area 0.1256 sq. mm. (Lauritzen and Wolford).

Group IV was the same as group III (15 degrees of movement).

Group V was the same as group III (5 degrees of movement). This study was done after the others were tabulated.

Adequate lighting is important, and the experiment was conducted at a bracket table of a dental unit with the unit light focused on the instrument. Binocular loupes were available for the use of the operators.

*The Lauritzen Research Group of the Postgraduate Department, University of Oregon Dental School.

The time required by each operator to locate the axis point was determined with a stop watch for groups I, II, III, and V and with a conventional watch for Group IV.

FACTORS INFLUENCING THE RESULTS

During the experiment, certain factors became apparent which were reflected in the results:

1. Training in this type of procedure led to better scores. Operators accustomed to work within close limits and fine tolerances fared better than those whose work was of a less demanding nature.

TABLE I. RESULTS OF GROUP I (NO EXPERIENCE) (10 DEGREES OF MOVEMENT)

TRIAL	OPERATOR									
	1		2		3		4		5	
	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME
1	0.6	4:45	1.0	12:00	0.4	7:00	0.8	5:30	0.6	3:50
2	1.5	7:10	0.6	6:00	0.4	10:30	0.8	5:20	0.6	4:55
3	1.5	5:10	0.6	6:00	0.4	6:00	0.6	2:40	0.4	2:15
4	0.8	5:30	0.4	7:00	0.4	3:00	0.4	5:30	0.8	4:50
5	0.4	4:50	0.4	5:00	1.0	12:00	0.4	2:20	0.6	3:55

Accuracy is expressed in millimeters of diameter, time of location in minutes.

2. Interest played a strong part in accuracy attained. Those who were not interested in the results were easily confused and gave up readily. Mental attitudes were closely correlated with the results throughout the entire series.

3. Physical characteristics had an effect on the results. Greater age retarded the tests and was accompanied by earlier and greater fatigue. Those with vision problems did not score as well and had greater difficulties.

4. Those accustomed to working with binocular loupes relied heavily upon them, and, with only a few exceptions, they were more accurate.

RESULTS

The results are shown in Tables I through V.

In the entire series of 190 locations, all were within an area with a diameter of 1.5 mm. Only three were in an area with a diameter larger than 1 mm.

In group I, 40 per cent of the locations were within 0.2 mm. of the axis.

In group II, 57 per cent of the locations were within 0.2 mm. of the axis.

In group III, more than 95 per cent of the locations were within 0.2 mm. of the axis.

TABLE II. RESULTS OF GROUP II (SOME EXPERIENCE) (10 DEGREES OF MOVEMENT)

TRIAL	OPERATOR											
	1		2		3		4		5		6	
	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME
1	0.8	3:00	1.0	4:40	0.6	2:35	0.6	3:15	0.4	1:45	0.6	1:15
2	0.4	4:00	1.5	2:40	0.6	2:25	0.4	2:25	0.4	1:10	1.0	1:50
3	0.6	3:00	0.8	2:34	0.4	2:30	0.4	2:45	0.4	1:30	0.8	2:40
4	0.6	4:00	0.4	3:40	0.4	2:55	0.4	3:25	0.4	1:40	0.8	2:00
5	0.4	3:00	0.4	3:55	0.4	2:15	0.4	2:15	0.4	0:55	0.4	1:40

TABLE III. RESULTS OF GROUP III (EXPERIENCED) (10 DEGREES OF MOVEMENT)

TRIAL	OPERATOR																	
	1		2		3		4		5		6		7		8		9	
	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME
1	0.4	3:30	0.4	1:35	0.4	3:55	0.4	5:15	0.4	3:00	0.4	1:40	0.4	2:55	0.4	1:45	0.4	4:15
2	0.4	1:40	0.4	1:15	0.4	2:40	0.4	2:15	0.4	4:00	0.4	1:45	0.4	2:00	0.4	1:05	0.6	4:25
3	0.4	2:00	0.4	1:10	0.4	2:40	0.4	2:20	0.4	1:30	0.4	0:50	0.4	1:50	1.0	0.45	0.4	2:05
4	0.4	2:00	0.4	1:45	0.4	2:45	0.4	1:10	0.4	1:00	0.4	1:50	0.4	1:15	0.4	1:30	0.4	3:10
5	0.4	1:30	0.4	1:00	0.4	2:00	0.4	2:35	0.4	2:55	0.4	1:00	0.4	1:10	0.4	1:45	0.4	1:25

TABLE IV. RESULTS OF GROUP IV (EXPERIENCED) (15 DEGREES OF MOVEMENT)

TRIAL	OPERATOR																	
	1		2		3		4		5		6		7		8		9	
	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME
1	0.4	4:00	0.4	7:00	0.4	2:30	0.4	2:00	0.4	1:30	0.4	3:00	0.4	3:30	0.4	3:00	0.4	4:00
2	0.4	2:00	0.4	7:00	0.4	2:30	0.4	2:30	0.4	1:30	0.4	3:00	0.4	3:00	0.4	1:30	0.4	5:00
3	0.4	4:00	0.4	5:00	0.4	1:20	0.6	7:00	0.4	2:00	0.4	2:30	0.4	3:00	0.4	2:30	0.4	3:00
4	0.4	4:00	0.4	3:00	0.4	0:50	0.4	3:00	0.4	2:00	0.4	3:00	0.4	1:00	0.4	2:30	0.4	2:00
5	0.4	4:00	0.4	10:00	0.6	1:00	0.4	1:30	0.4	2:30	0.4	4:30	0.4	1:30	0.4	2:00	0.4	2:00

TABLE V. RESULTS OF GROUP V (EXPERIENCED) (5 DEGREES OF MOVEMENT)

TRIAL	OPERATOR																	
	1		2		3		4		5		6		7		8		9	
	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME	ACCURACY	TIME
1	0.6	6:30	0.8	2:10	0.4	8:45	0.4	4:40	0.6	3:40	0.4	4:30	0.4	6:20	0.4	7:40	0.4	5:20
2	0.4	3:10	0.6	3:00	0.4	2:50	0.4	2:34	0.8	4:50	0.4	4:00	0.4	3:15	0.4	4:50	0.4	4:45
3	0.6	2:10	0.8	6:00	0.4	2:55	0.4	3:35	0.6	4:25	0.4	9:10	0.4	11:05	0.4	8:50	0.4	11:05
4	0.4	3:15	0.8	8:45	0.4	4:40	0.4	2:55	0.4	5:50	0.4	3:30	0.6	6:30	0.4	3:10	0.4	11:35
5	0.4	1:45	0.4	7:00	0.4	4:15	0.4	3:20	0.4	4:59	0.4	3:20	0.8	2:35	0.4	3:20	0.4	5:15

In group IV, with 15 degrees of movement, more than 95 per cent of the locations were within 0.2 mm. of the axis. The similarity of findings in groups III and IV indicates that 10 degrees of movement is as effective as 15 degrees; it is adequate for hinge axis location.

In a comparison of the tables, it is noted that group III, using 10 degrees of movement, made the locations in noticeably shorter time than when they used 15 degrees of movement. This is ascribed to the fact that the tests with 15 degrees of movement were conducted first, and at that time the operators were unfamiliar with the test instrument.

It may also be noted that group V, utilizing only 5 degrees of motion, usually took a longer time. With this limited range of motion, it became much more difficult to locate the point.

DISCUSSION

By adapting conventional articulators to open and close through a range of only 10 degrees for a series of tests, Kurth and Feinstein[6] were able to locate the hinge axis of the articulator within an area about 2 mm. in diameter, while Borgh and Posselt[7] found the located points to be in an area 1.5 mm. in diameter. The findings in groups III and IV, with an instrument designed to test the accuracy of locations with the same range of motion when operated by men who have performed hinge axis locations on a clinical basis, were within an area 0.4 mm. in diameter in more than 95 per cent of the attempts. The reliable area of location was found to be one-fourteenth of that shown by Borgh and Posselt and one–twenty-fifth of that found by Kurth and Feinstein (Fig. 6).

No attempt is made made to compare the findings of group V, since no previous experiments using this smaller range of motion have been performed. It is felt, however, that in view of the extremely limited motion, the fact that 75 per cent of the locations were within 0.2 mm. of the axis adds strong confirmation to the theory that accuracy is attainable under ordinarily limited circumstances.

SUMMARY

An experimental instrument was designed to determine how accurately the center of 15, 10, and 5 degree arcs of movement could be located consistently. It was designed to eliminate, as nearly as possible, any mechanical errors which would influence the results of the experiment. The tests were conducted in a manner as nearly blind as possible. With a variety of subjects to operate the instrument, several series of axis locations were performed.

The results indicate not only that a 10 degree range of movement is sufficient for hinge axis location but that when dentists experienced in axis location are tested on an experimental apparatus, the attainable accuracy in locating the center of the 10 degree arc is within 0.2 mm.

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C. E. LUCE'S RECORDINGS OF MANDIBULAR MOVEMENTS

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LUCE IS KNOWN for his introduction[1] in 1889 of the photographic method of registration of jaw movements. He also developed the chew-in method of intraoral registration of mandibular movements and the transfer of these records to an articulator.[2,3]

This article draws attention to some aspects of Luce's registrations of the movements of the lower jaw[1] and relates them to a modern concept of mandibular movements. A short description of Luce's registration method as well as a summary of his conclusive statements is given in addition to a simplified review of the original recordings.

LUCE'S TECHNIQUE

Registration Method.—A framework (clutch) fastened to the lower incisor teeth carried "bright beads which could be placed directly opposite the condyle, angle and symphysis. . . . It is apparent that the jaw and device will move in concert, and that the movement of the beads is, in fact, the same as that of the points opposite to which they are placed. . . . With the subject in a strong sunlight, so that a bright spot should be reflected from the bead, a pure profile or side view was photographed, and the sensitive plate was exposed during the opening of the mouth. The bright spot reflected from the bead during the motion was continuously photographed and its excursion recorded on the negative as a line, giving the actual movement of the place upon the jaw to which the bead was opposed. . . . The picture was enlarged in outline by optical projection, and the tracing of the opening at symphysis was subdivided into convenient spaces; then, by means of dividers, corresponding points in the tracings at condyle and angle were determined . . . ."[1]

Registrations.—Luce registered several opening movements in the sagittal plane: "normal opening" (Fig. 1), opening "after protrusion" (Fig. 2), and making an effort to "keep the condyle back while opening the mouth" (Fig. 3).

Luce's registration of opening and closing movements "with the subject facing the camera" will not be discussed.

Conclusions.—"The condyle begins to move forward immediately, and even in a small opening of the mouth it performs quite a considerable excursion. . . . The condyle advances even if an effort is made to hold it back.

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Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1.—A normal opening movement is redrawn after Luce. (Subdivisions are not included.)

Fig. 2.—An opening "after protrusion" movement is redrawn after Luce. (Subdivisions are not included.)

Fig. 3.—Attempt "to keep the condyle back while opening the mouth" is redrawn after Luce. (Subdivisions are not included.)

". . . The forward movement [of the condyle] is most rapid in the middle of its course. . . . The condyle does reach the summit of the eminence and even begins to mount the anterior side.

". . . There is considerable individual variation in the relative movements of condyle, angle and symphysis."

COMMENTS ON LUCE'S REGISTRATIONS

Luce's registrations of mandibular movements are discussed only with regard to movement of the mandible in the median (sagittal) plane.

The first consideration concerns the movement area of a point on the anterior part of the mandible in the median plane shown by modern research. The mesioincisal angle of the lower left central incisor and infradentale (the uppermost and most anterior point of the bony septum between the lower incisors) are the points on the mandible which have been used in most registrations of the area.[4,5,8,9] Habitual opening and closing movements may be recorded simultaneously for comparative purposes.[4]

According to Posselt,[9] a figure representing the average movement area of the mandible on the median plane shows these characteristics (Fig. 4):

"1. The extreme posterior opening is indicated by the line *RC-M*. Its upper part is the hinge movement, *H*, which can be made to from 2 to 2½ cm. of opening. Retruded positions at different degrees of opening inside the hinge-opening range lie on the hinge-movement path.

"2. The extreme opening movements differ from the habitual opening and closing movements.

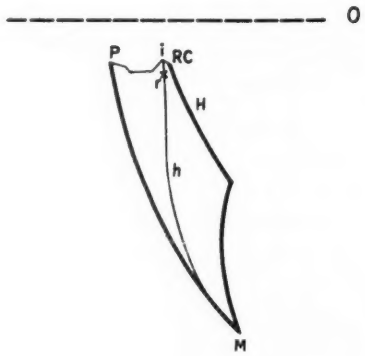

Fig. 4.—"Average movement area on median plane, showing habitual closing movement *(h)*, rest position *(r)*, line parallel to occlusal plane *(O)*, retruded contact position *(RC)*, occlusal (intercuspal) position *(i)*, protruded contact position *(P)*, hinge movement *(H)*, and maximal open position *(M)*. Approximately natural size."[9] (Reduced ¼.)

"3. Posterior hinge movement is a pure rotation around an intercondylar axis. No other path of opening is concentric with it, and none of the other opening paths are of the same character.

"4. The anterior extreme opening is not a hinge movement since it is not concentric with the hinge-movement path because the condyles move further forward when the mandible moves from the maximal protruded contact position, *P*, to maximal opening, *M*.

"5. The forward and backward glide between *RC* and *P* is somewhat irregular because of incisal and other tooth guidances."

Luce's registrations correspond to Posselt's in the following manner:

Movements Recorded by Posselt.—

1. "Anterior extreme opening."
2. "Posterior extreme opening."
3. "The forward and backward glide."
4. "Habitual closing movement."

Movements Recorded by Luce.—

1. "Opening after protrusion."
2. Making an effort "to keep the condyle back while opening the mouth."
3. "Protrusion."
4. "Normal opening."

Fig. 5.—Luce's records of opening "after protrusion" (Fig. 2) and trying "to keep the condyle back while opening the mouth" (Fig. 3) are redrawn on an enlarged, common scale and placed one upon the other. Note a movement area on the median plane of a point slightly in front of the mandible. (Subdivisions are not included.)

Luce's recordings of "opening after protrusion" and making an effort "to keep the condyle back while opening the mouth" were redrawn in a simplified manner on an enlarged common scale and placed on top of each other. Thus, one picture shows both registrations (Fig. 5) and illustrates a movement area of a point slightly in front of the mandible. This movement area is remarkably similar to the movement area shown by Posselt (Fig. 4).

The tracing of the "normal opening" (Fig. 1) does not differ much from the habitual closing movement shown by Posselt (Fig. 4). The rest position of the

mandible was not recorded by Luce. Luce registered border movements and a habitual movement ("normal opening") and demonstrated the distinction between these movements.

Posselt has shown that terminal hinge opening and closing movements may extend to a distance of 20 mm. between the incisors[5,7] with the axis of rotation being a line through the condyles.[6] Luce differs with "the assertion of Gray and others to the effect that in small openings the condyles simply rotate on a transverse axis against the fibrocartilages." However, when Luce's recordings (Figs. 3 and 5) are checked, the upper part of the extreme posterior opening suggests a hinge movement corresponding to an opening of 15 to 20 mm. As already mentioned, Luce's "tracing of the opening at the symphysis was subdivided into convenient spaces; then, by means of dividers, corresponding points in the tracings at the condyle and angle were determined . . . ." The difference of opinions may be due to the accuracy or inaccuracy with which the dividers were used.

Movements of the symphysis during opening and closing of the mouth were recorded "with the subject facing the camera." Luce pointed out that "the jaw is not depressed or closed in a straight line; the tracings taken contain several curves, which will vary with the same person at different times . . . ."

DISCUSSION

Luce presented only three registrations of mandibular movements in the median plane, one each of the border movements (including the protrusive movement) and one of the habitual opening movement. The recording beads were placed at a certain (not specified) distance from the mandible. This entails changes in the size as well as in the shape of the recordings.

The original pictures were redrawn for this article on a common, enlarged scale to obtain a combined picture of the recorded border movements.

SUMMARY

A review of C. E. Luce's recordings of mandibular movements in the median plane, a description of his photographic method of registration, and a résumé of his conclusions have been presented.

The movement area on the median plane of a point in front of the mandible was obtained by combining Luce's different recordings into a single drawing. The shape of this figure conforms to the average movement area as registered by Posselt and, furthermore, suggests the registration of a terminal hinge opening movement, which appears to have escaped Luce's attention.

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WALKER'S IMPROVEMENTS OF BONWILL'S SYSTEM

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BENNETT'S ARTICLE, "A Contribution to the Study of the Movements of the Mandible," was republished[1] because of its significance to prosthetic dentistry. W. E. Walker[2-4] is another prosthodontist whose study of occlusion has resulted in a valuable contribution to the development of prosthetic dentistry.

Walker carried further the work of Bonwill and presented his findings in a series of articles that appeared in *Dental Cosmos* in 1896-1897. The contents of these articles will be reviewed and illustrated by some of the original pictures.

WALKER'S OBSERVATIONS

Walker found that complete dentures constructed according to Bonwill's instructions using Bonwill's Anatomical Articulator lost the perfect occlusion obtained on the articulator when placed in the patient's mouth. This led him to studies of the cusps of the teeth, the glenoid fossae, and the movements of the mandible.

Cusps of the Teeth.—The lingual cusps of the upper teeth are "longer" than the buccal cusps, and the buccal cusps of the lower teeth are "longer" than the lingual cusps. There is a "variation of the long axis of the tooth from the vertical direction." The upper molars lean buccally, the lower molars lingually. The difference in cusp height and in axis inclination increases distally.

The distolingual and the buccal cusps of the upper molars become "less in area" toward the ramus. The distolingual cusp in many instances is entirely missing on the third molar. The mesiolingual cusps of the upper molars increase distally but not sufficiently to prevent the teeth from becoming gradually smaller.

"There is a certain definite co-relation between the morphology of the morsal (occlusal) surfaces of the teeth, and the angle made by the intersection of the functional portion of the condyle path with the facial line" (the line touching the most prominent points of the median plane of the face, excepting the nose).

Glenoid Fossa.—"That portion of the roof of the glenoid fossa which affords articulation to the condyle of the mandible has a forward and downward slant or incline."

Movements of the Mandible.—As a consequence of the inclined "roof of the glenoid fossa," the condyles move forward, as demonstrated by Bonwill, *and also downward.* The ramus descends about 3 mm. both during opening of the mouth

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and when the incisors are brought into an edge to edge contact. In lateral movement of the mandible, the ramus descends on the balancing side only as the condyle on the working side moves *upward and backward*. This condyle does not remain stationary with a rotation on its axis as asserted by Bonwill.

"The course which the condyle travels" is at an angle to the plane of occlusion. The average size of this angle is 35 degrees. About 15 mm. below "the upper surfaces of the condyle" at the back of the ramus, there is a point which does not move backward or forward during the opening movement.

FAULTS IN BONWILL'S THEORIES

Walker pointed out two fundamental errors in Bonwill's system: (1) the equalization of the cusp heights and (2) the parallelism of the plane of occlusion with the condyle movement in Bonwill's Anatomical Articulator.

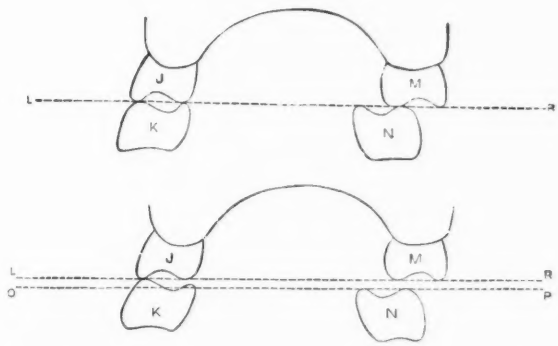


Fig. 1.—*A*, Bonwill's diagram shows that the buccal and lingual cusps are equal in length. *B*, The drop of the condyle on the balancing side during a lateral movement causes a space between cusps of equal length. (From Walker, W. E.: D. Cosmos **38**:39, 1896.)

Cusp Heights of the Teeth.—Bonwill stated that "the inner [lingual] cusps of the upper [teeth] should as a rule be longer or higher than the outer." Nevertheless, Bonwill reduced the length of the lingual cusps until they were equal in length with the buccal cusps. "The drop of the condyle" on one side during lateral movement produces the relationship between the teeth shown in Fig. 1.

Proper occlusion could not be obtained even if the cusp heights were not reduced. In lateral movements of the jaw, the lingual cusps of the upper molars rest upon the buccal cusps of the lower molars on the balancing side. The result would be a space of about 3 mm. between the teeth on the working side. Biting would be prevented because the molars would hold the incisors entirely apart.

Bonwill's Anatomical Articulator.—The plane of occlusion was parallel to the plane of condylar movement in Bonwill's Anatomical Articulator. Consequently, only condyle movements parallel to the plane of occlusion could be reproduced. Walker never found these planes to be parallel.

WALKER'S CONTRIBUTIONS TO THE IMPROVEMENT OF BONWILL'S SYSTEM

Walker modified Bonwill's Anatomical Articulator, constructed the Facial Clinometer, and used artificial teeth with cusp heights in accordance with his observations of natural teeth.

Walker's Modifications of Bonwill's Anatomical Articulator.—Bonwill's Anatomical Articulator had to be modified so that a condyle path of 35 degrees could be obtained to reproduce the correct articulation of casts of natural teeth.

The Walker-Bonwill Articulator was further developed into Walker's Physiological Articulator (Fig. 2). This articulator has an adjustable angle with a gauge to register the degree of the angle at which teeth of casts of different jaws occlude. Further, "it is necessary that the articulator be provided with a variable angle, . . . as the angle of the slant or incline is not the same in all subjects, varying in extreme cases from 30 degrees to 45 degrees within the limits of the normal," varying "not only in different subjects, but also very considerably in the movements of the two condyles of many individuals."

Facial Clinometer.—Walker constructed a measuring device called the Facial Clinometer (Fig. 3). This instrument made it possible to measure, among other things, the direction of the condyle paths and the plane of occlusion in relation to the facial line. With the Facial Clinometer, he confirmed his observations of the movements of the condyles during mastication.

Walker realized the importance of recognizing and measuring the extent and direction of the backward and upward movement of the condyle on the working side and of the correct reproduction of this movement in the articulator (Fig. 4).

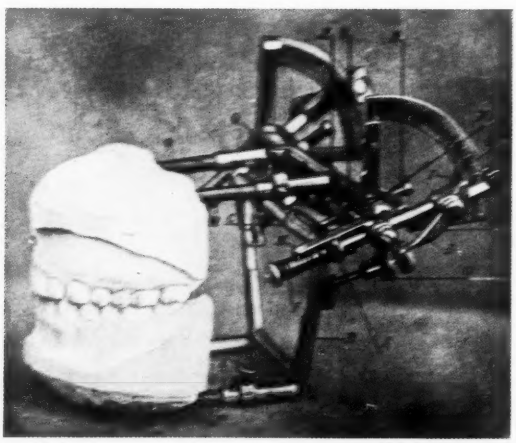
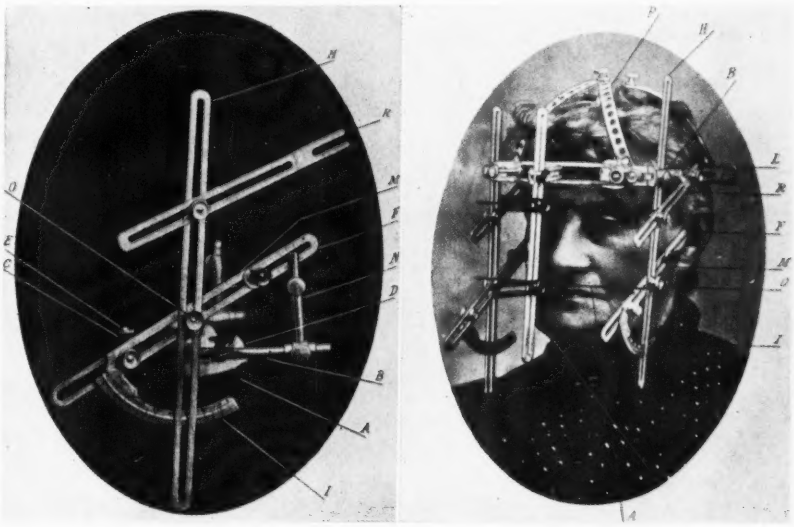


Fig. 2.—The Walker Physiological Articulator was developed from Bonwill's Anatomical Articulator. *E* is a bite-correcting fulcrum screw used to correct the bite when it is either too far forward, too far back, or falsely to one side or the other; *F* is another fulcrum screw which can be instantly removed with its supporting frame, *G*, since it is only used in correcting a bite which is too close or not close enough; *H* is divided in its center so that the condylo-occlusal angle of one side may be adjusted independently of the other; *G* is an adjustable sliding collar which carries the bite-correcting fulcrum screw, *F*, which passes through a slot in *E* so that it is always parallel with the bar, *H*, which controls the condyle movement. (From Walker, W. E.: D. Cosmos **39**:794, 1897.)



A. *B.*

Fig. 3.—*A*, The Facial Clinometer is attached to the patient. *B*, One side of the Clinometer is detached from the head support. (From Walker, W. E.: D. Cosmos 39:797, 1897.)

"The mandible, as we know, is based on the equilateral triangle, the sides measuring four inches. In the diagram *A* and *B* represent the condyles, *C* the point between the central incisors. If we imagine that the mandible is thrown to the left, and that the left condyle *A* does not recede, *B*, the condyle of the right side, takes the position *B'*, while *C*, the medial line of the incisors, travels to *C'*. In the molar region *F* travels to *F'* on the left, and *H* to *H'* on the right. But in a case in which the right condyle *B* advances the same distance as before, while the left condyle *A* recedes one-third of that distance, moving to *A''*, we will find that the entire triangle acts as though turning on the fulcrum *D*. *C*, instead of moving to *C'*, will reach *C''*, while *F* will have moved to *F''*, and *H* to *H''*.

"In constructing a set of teeth for a subject in whom, by reason of the condyle receding on the guiding side, the fulcrum is at *D* as shown, instead of at *A*, if by reason of the construction of the articulator the fulcrum is immovably fixed at *A*, instead of being movable to suit the case, we should find the articulation at fault to the extent of the difference between the points *F'* and *F''*, *H'* and *H''*, *C'* and *C''*, respectively, causing inevitable interference of the cusps, necessitating either the sacrifice of the cusps or the reconstruction of the set."

Artificial Teeth.—Walker demonstrated that dentures with proper occlusion on Bonwill's Anatomical Articulator lost this occlusion when placed in Walker's Physiological Articulator.

The lingual cusps of the upper teeth increased in height from the bicuspid to the third molar in dentures constructed according to Walker's ideas. The cusps did not interfere in lateral movements of the jaw because of the drop of the posterior part of the jaw. This drop is reproduced in his articulator. His diagram (Fig. 5) shows balanced occlusion in the mouth and on the articulator.

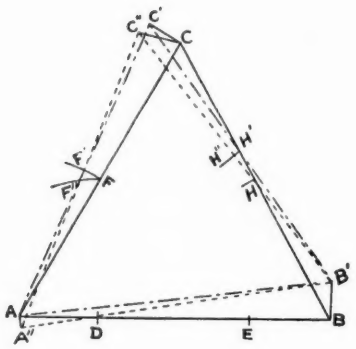


Fig. 4.—Walker's diagrammatic illustration of a left lateral excursion of the mandible. (From Walker, W. E.: D. Cosmos 39:798, 1897.)

Walker also recalled the results obtained by Black with his gnathodynamometer which showed the advantage of high cusps in masticating food with dentures. Walker asserted that the overlap of the incisors should be made less than normal, because otherwise "the curve of the distal end of the interdental line" had to be considerably increased "to have the molars balance the incisors and support the plates in incising."

SUMMARY

Walker called attention to faults in recognized theories and methods on the basis of studies of anatomy and physiology. He constructed the first adjustable articulator, as well as an apparatus with which the direction and extent of the condyle path could be measured. He found that the average sagittal condyle path was 35 degrees. (About 10 years later, Gysi[5] stated that 33 degrees was the average in Switzerland.) Walker also reproduced the occlusion of natural teeth on his articulator.

Walker observed that the condyle of the working side moved upward and backward during a lateral movement of the mandible from centric occlusion. This movement of the condyles into their most retruded position from centric occlusion has often been observed[6,7] and has caused much confusion in the discussion of centric occlusion.

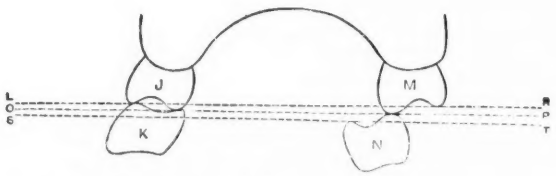


Fig. 5.—The drop of the posterior part of the jaw during a lateral movement of the mandible is reproduced in Walker's articulator, and balanced occlusion is maintained. (From Walker, W. E.: D. Cosmos 38:40, 1896.)

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CONTROL OF INCREASED VERTICAL DIMENSION OF COMPRESSION-MOLDED DENTURES

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AN INCREASED VERTICAL DIMENSION OF OCCLUSION after the processing of dentures has long been recognized as a serious problem. The grinding of the occlusion to correct processing changes is an essential part of most complete denture techniques. Cuspal form and selected tooth structure must be modified frequently, and the vertical dimension of occlusion is greater than planned because of this increase in vertical height of the dentures. In addition, centric occlusion will be slightly anterior to the centric relation which was recorded on the articulator.

During curing, a 3 to 4 per cent expansion of the resin mass occurs before polymerization and is coupled with the possibility of a 4 per cent elastic deformation of the investing artificial stone from packing pressures.[1] The cured acrylic resin exhibits a 6 to 7 per cent volumetric shrinkage, which is a 2 per cent linear shrinkage.[1,2] The actual shrinkage of a denture between the posterior borders has been measured and found to be 0.5 per cent. The rest of the shrinkage is incorporated into the denture as unresolved stresses resulting from a combination of curved surfaces, varying degrees of direction of curvature, and uneven distribution of bulk.[3] Porosity and excessive shrinkage result when there is too little resin in the mold.

At one time, it was felt that the shrinkage of acrylic resin could be compensated for by the introduction of compressive stresses (overpacking and high packing pressures) so that shrinkage would tend to relieve the strains rather than lead to a decrease in volume of the denture. Subsequent techniques called for densifying the resin with test packs and then allowing the packed resin to age on the bench 1 hour before curing.[2]

Grunewald[4] reported that the most important factor in increasing the vertical dimension of occlusion was excess acrylic resin in the mold at the time of final closure. Rapid closure of the flask, curing in a plaster mold which was not completely set, using a thin investing mixture, or failure to use a spring clamp did not appreciably affect the vertical opening. He also suggested the removal of some resin from the mold just before the final closure.*

METHODS

A pilot study of differences in vertical dimension was devised for the freshman denture technique laboratory at the Medical College of Virginia, School of Dentistry. The dentures made by 80 students were divided into six groups. Each group

*A. H. Grunewald: Personal communication.

made a single modification in the flasking and packing procedure to study its effect on the vertical dimension of occlusion.

All students used Hanau model H articulators, similar casts and jaw relationships, and 30 degree porcelain teeth. All dentures were of similar form and shape.

At the time of approval of the wax-up and immediately before the investment, the condylar guidances were locked, the dentures were closed into occlusion, and the incisal guide pin was brought solidly against the incisal guide table. A measurement of the height of the incisal guide pin in relation to the bottom of the upper member of the articulator was made with a Boley gauge.

The cast and the wax denture pattern were invested in the bottom half of the flask. The second layer of investment was a half plaster, half artificial stone mixture carried up to the occlusal and incisal edges of the teeth. The third layer of investment was of artificial stone, and it filled the flask. All molds were test packed until no excess resin was evident.

VARIATIONS IN METHODS

Group I was the control group. The flasks were test packed and closed and placed in spring presses without modification. Group II removed a small plug of acrylic resin about the size of a pea from the resin in the palate of the upper denture mold before final closure. A pencil with the eraser removed was used as a punch to remove the material. Group III added a piece of resin about the size of a pea to the resin in the mold for the upper denture. Group IV added a similar size piece of resin to both the upper and lower denture molds. Group V removed a small plug of material from the resin in the lingual flange of the lower denture mold. Group VI removed a plug of material from both the upper and lower denture molds.

The dentures were cured for 8 hours at 165° F., then boiled 1 hour, bench cooled, deflasked, and remounted on plaster mountings by keyways cut into the artificial stone casts. New measurements were made of the incisal pin height with the condylar guidances locked and then unlocked. The teeth usually came closer together and the condyle balls moved slightly backward when the condylar guidances were unlocked. The void was not completely closed in two of the forty-five dentures

TABLE I. EFFECT OF AMOUNT OF RESIN IN THE MOLD (LABORATORY DENTURES)

PACKING PROCEDURE	NUMBER OF DENTURES	AVERAGE VERTICAL GAIN (MM.)	
		LOCKED	UNLOCKED
Trial packed without excess	11	1.2	0.9
Resin plug removed from the palate	11	1.1	0.9
Resin added to the palate	11	1.3	1.1
Resin added to upper and lower dentures	10	1.3	0.8
Resin plug removed from the lower denture	10	1.2	0.8
Resin plug removed from both upper and lower dentures	12	0.8	0.5

from which a plug of resin was removed. Dentures which had obvious movement of a single tooth or which had obvious student error were not considered in the averages shown in Table I.

Results.—Although there was a considerable range of variations in the measurements for each group, the addition of acrylic resin to the mold increased the vertical dimension of the dentures. The removal of acrylic resin before final closure reduced the amount of increase of the vertical dimension, particularly when material was removed from both the upper and lower dentures (Table I).

SECOND LABORATORY STUDY

A similar study was done the succeeding year in the freshman technique laboratory. The basic form of the first study was followed except that a different resin was used and all dentures were cured for 9 hours at 165° F. without subsequent boiling.

TABLE II. EFFECT OF WATER IMMERSION AND ESCAPEMENTS (LABORATORY DENTURES)

PACKING PROCEDURE	NUMBER OF DENTURES	AVERAGE VERTICAL GAIN (MM.)	
		LOCKED	UNLOCKED
Trial packed without excess	11	1.4	1.2
Second investment immersed in water at 50° F.	14	1.0	0.8
Second investment cooled in water at 50° F. without water contacting investment	11	1.3	1.2
Escapements on upper and lower dentures in first molar regions	13	0.6	0.5
Escapements on upper and lower dentures in cuspid regions	11	0.8	0.6
Escapements at upper cuspids and lower molars	10	0.5	0.3

Group I was the control group. Group II placed the flask into 50° F. water completely covering the investment while the second layer of investment was setting. This was done to allow hygroscopic expansion of the investment and to dissipate the heat of the setting of the artificial stone. Group III placed the flask in 50° F. water without allowing the water to contact the investment at the time the second investment layer was setting. Groups IV, V, and VI used escapements added onto the waxed denture after investment in the bottom half of the flask.

The escapements were 10 mm. wide and two layers of baseplate wax in thickness. Each group placed the escapements in different locations, but they all extended from the denture base to the inside edge of the flask. When the wax was

TABLE III. CHANGES IN CLINICAL DENTURES

PACKING PROCEDURE	NUMBER OF DENTURES	AVERAGE VERTICAL GAIN (MM.)	
		LOCKED	UNLOCKED
Trial packed without excess	10	1.9	1.5
Second layer of investment immersed in cold water	9	1.5	1.1
Escapements at cuspid regions on upper and lower dentures	7	1.3	0.9
Escape areas at cuspid regions on upper and lower dentures and cold water surrounding flask at time of second investment	8	1.1	0.9

boiled out, there were spaces in the second investment layer that corresponded to the wax extensions from the wax pattern of the denture.

All molds were packed without excess resin. At the time of final closure of the flasks, all resin was removed from the escapements by groups IV, V, and VI. After curing, the escapements were usually full. Experimental packing showed that the escapements usually refilled shortly after final closure of the flask (Table II).

Results.—Immersing the second investment layer in 50° F. water reduced the increase in the vertical dimension 29 per cent. However, merely allowing 50° F. water to surround the flask without contacting the investment did not help appreciably. The use of escapements on the upper and lower dentures reduced the increase in the vertical dimension by 57 per cent. Their location did not make any appreciable

TABLE IV. DIMENSIONAL CHANGES

TECHNIQUE SPECIMEN	TOTAL PERCENTAGE CHANGE IN DIMENSION FROM SECOND MOLAR TO SECOND MOLAR					
	FLASKING TO OCCLUSAL SURFACE	CURING	DEFLASKING	REMOVAL FROM MODEL AND POLISHING	IMMERSION IN 76° F. WATER FOR 3 WEEKS	GAIN IN VERTICAL DIMENSION
Control, trial packed						
Upper denture	−0	−0.1	−0.1	−0.4	−0.4	1.1 mm.
Lower denture	−0	+0	−0.4	−0.3	−0.4	
Molar escapements						
Upper denture	+0.1	+0	−0.2	−0.4	−0.3	0.5 mm.
Lower denture	−0	−0	−0.4	−0.3	−0.4	

difference. Porosity ranging from slight to heavy was noted in half of the dentures in which escapements were utilized, indicating that the size of these spaces had been too large (Table II).

CLINICAL TESTS

Clinical dentures were measured and divided into groups for testing on the basis of the first laboratory study. The clinical measurements were made at random, with no attempt at uniformity concerning size of the bearing area, tooth material, tooth arrangement, or cuspal inclinations. When escapements were used, they were 5 mm. wide and the thickness of two layers of baseplate wax extending from the denture to the inside edge of the flask. The material was not removed from these escapements during test packing, but the resin in the escapements was removed just before the final closure of the flask.

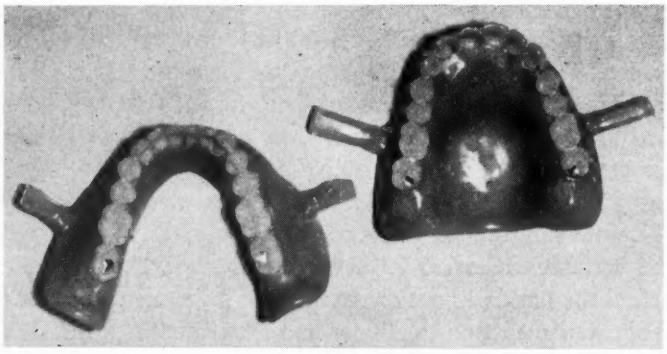

Fig. 1.—A technique denture was cured with escapements from which all resin was removed at the time of final closure of the flask. Occlusal gold foil fillings in the second molars serve as reference points for intermolar measurements.

Two dentures were constructed on similar casts with similar mountings and similar teeth to check the possibility of excessive shrinkage in the dentures made when escapements were used.

Gold foil fillings were placed in the second molars, and marks were made in them which could be observed with a measuring microscope (Fig. 1). The vertical dimension of occlusion was recorded before and after curing. One denture was used as a control and was trial packed three times without excess resin. The other denture had escapements and was packed similarly. The material was removed from the escapements just before final closure. This was the only difference between the two dentures. The distance between the second molars on each denture was recorded at various times during and after curing.

Results.—The clinical control dentures had more vertical opening than the technique dentures. This fact emphasizes the importance of occlusal grinding to remove these changes after processing. Immersing the second investment layer in cold water caused a reduction of the increase in the vertical dimension. The use of escapements

caused a greater reduction of the increase of vertical dimension than immersion in water. Porosity was not a problem with escapements 5 mm. wide. However, porosity was noted occasionally at the junction of the escapement with the denture base. The clinical tests correlated well with the laboratory studies (Table III).

Dimensional Changes.—There were no appreciable differences in intermolar distance between the dentures with and without escapements, indicating that they do not cause excessive shrinkage. Both dentures exhibited the greatest shrinkage at the time of removal from the casts. The denture with the escapements showed slightly more than a 50 per cent reduction of the increase of the vertical dimension of occlusion. There was no porosity in either denture (Table IV).

SUMMARY AND CONCLUSIONS

The increase of the vertical dimension of occlusion of more than 171 dentures was measured and studied. The important findings were:

1. The increase in the vertical dimension of occlusion can be reduced about 50 per cent by making a provision for the excess resin in the mold to escape from the mold *after* the final closure.

2. Dentures that utilize escapements do not have any more dimensional change in the distance between the molars after curing than do dentures cured without escapements.

3. Porosity is not a problem if the escapements do not exceed 5 mm. in width or two layers of baseplate wax in thickness.

4. The resin must be condensed by test packings before it is removed from the escapements.

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REMOVABLE PARTIAL DENTURES

ROENTGENOGRAPHIC STUDY OF BONE CHANGES DURING EXERCISE STIMULATION OF EDENTULOUS AREAS

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ONE OF THE FUNDAMENTALS of prosthodontic service is that of preserving the remaining oral structures in an optimal state of health while restoring to function those parts of the masticatory organ which have been lost.[1]

Undoubtedly, the most distressing problem that confronts the prosthodontist in his efforts to render satisfactory service is the lack of adequate subbasal structures on which to support the prosthesis.

This problem becomes particularly acute when it is necessary to replace missing posterior teeth in the mandible by means of a free end extension partial denture. Severe loss and depletion of subbasal structure in the edentulous areas through prolonged disuse, disease processes, or mechanical trauma may drastically reduce the success of an appliance in these areas. Too often, the prosthodontist is confronted by a clinical situation in which he finds a severe reduction in physical bulk of the residual ridge with a history of prolonged absence of functional stimulation. The patient's history may reveal additional facts such as past episodes of systemic disease, endocrine disturbance, or periodontal disease which further darken the prospects of completely satisfactory service. To place a functional demand upon the subbasal structures under the foregoing circumstances would certainly lead to immediate and rapid loss of still more of the supporting tissues, with accompanying irritation and undesirable leverage increase on the abutment teeth.

The construction and placement of a prosthesis under conditions which will certainly destroy some of the remaining oral structures is not satisfactory. In restoring function, an effort must be made to preserve the remaining oral tissues. With this as an objective, a technique based upon the biologic and physiologic principles of bone formation and degeneration is proposed. The intent in this study is to

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*Based in part on the condensation of a thesis investigation carried out as a graduate student in prosthodontics at the Kellogg Institute of Graduate and Post-graduate Dentistry.

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demonstrate a method whereby a partially edentulous ridge which has been without functional stimulation for a long period of time can be restored to a state wherein it is capable of supporting a functional load *without an appreciable loss of physical bulk.*

REVIEW OF LITERATURE

Orban,[2] Weinmann and Sicher,[3] McLean and Urst,[4] Omnell,[5] and others have done extensive writing on the subject of bone, and they are generally in agreement about the development, composition, and physiology of the human skeleton as a whole.

The body of the mandible is described by Orban[2] as consisting of two parts: the portion which surrounds the roots of the teeth and gives attachment to the periodontal membrane (the alveolar bone proper) and that part which surrounds the alveolar bone and supports the socket (the supporting bone). The spongy (cancellous) portion of this supporting bone consists of a trabecular framework which supports vessels, nerves, marrow, and fat cells. When normal functional stresses are removed from an area of supporting bone, the trabeculae tend to decrease in bulk and the marrow spaces may become larger and the fatty content increased.[4] This condition has been referrd to as atrophy, osteoporosis, or rarefaction of bone, and many times the three terms have been used interchangeably. McLean and Urst[4] define these three terms as distinct variations: atrophy as loss of substance or volume, osteoporosis as increased porosity, and rarefaction as a decrease in density. Generalized agreement prevails, however, in that these conditions, or this condition, is the result of a physiologic dissolution of inorganic components of the bone matrix. The loss of 25 to 30 per cent of the bone salt is necessary to produce an apparent change of the bone as detected radiographically; in severe cases of atrophy, more than 50 per cent of the mineral skeleton may be lost.[4] It is usually stated that atrophy is the result solely of *deficient formation* of bone in the presence of a normal rate of destruction of this tissue. The causative factor may be disuse, senility, or disease processes. This study was made on subjects in whom the principal factor in loss of supporting bone was a long-standing absence of posterior teeth with resultant disuse atrophy.

HISTORY

The research literature of the past two decades includes reports of several studies which were made in an attempt to determine accurately by photometry of roentgenograms the quantitative mineral content of varying tooth and bone specimens.

Hodge and co-workers[6] carried out an extensive investigation of the accuracy of a method of determining the mineral content of a tooth slab under different experimental conditions. Roentgenograms were made of the specimen together with an aluminum penetrometer, and after densitometry, the mineral content of the tissue was given in millimeters of aluminum.

Stein[7] measured the density of various small areas of a roentgenogram with a simple densitometer and used an ivory step wedge for reference.

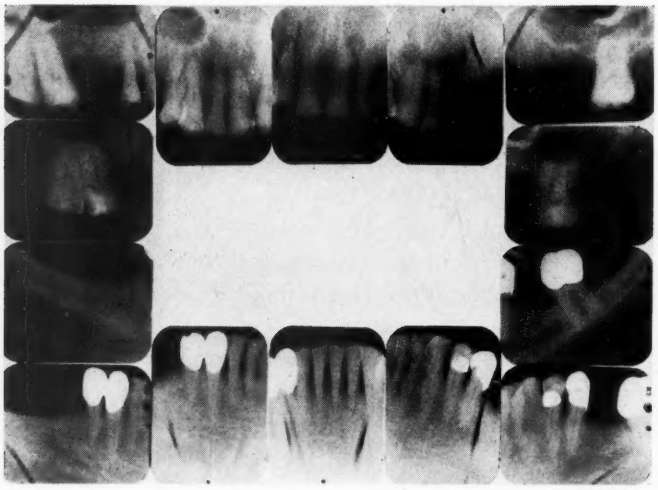


Fig. 1.—A severe loss of supporting bone has occurred in the edentulous areas, and there has been extensive loss of bone around the remaining teeth which have been subjected to prolonged overload. This condition indicates poor bone maintenance ability. Reconditioning of the edentulous areas by exercise therapy before restoring the function of missing teeth is especially needed in the treatment planning.

Bywaters[8] investigated changes in the metacarpal bones of patients with rheumatoid arthritis by use of photometry of roentgenograms with ivory cylinders of varying thickness for reference.

Engstrom and Welin[9] described a photometric method for quantitative roentgenologic determination of calcium salt in bone.

Omnell[5] presented a preliminary report of a roentgenologic photometric method according to which repair of periapical lesions could be followed quantitatively. Roentgenograms were made with identical projection from one examination to another, the "periodic identical technique."

Richards[10] presented the results of a study of measurement of radiopacity of human lip and mandible by means of roentgenologic photometry. He employed an aluminum penetrometer with a step wedge of known dimension of aluminum alloy as a reference. A simple method of interpolation was employed to evaluate radiopacity of tissue in exact units of aluminum alloy.

Omnell[5] described a method of measuring the mineral content of bone in living animals. His method employed the use of an aluminum step wedge and the periodic identical technique. Experimental injury was done to the alevolar bone, and the changes in mineral content were recorded.

SELECTION OF PATIENTS

Patients who required restoration of missing posterior teeth in the mandibular arch were selected for this study from the undergraduate clinic of the University of Michigan, School of Dentistry. Primary consideration was given to the length of time the individual had been partially edentulous—a period of not less than five

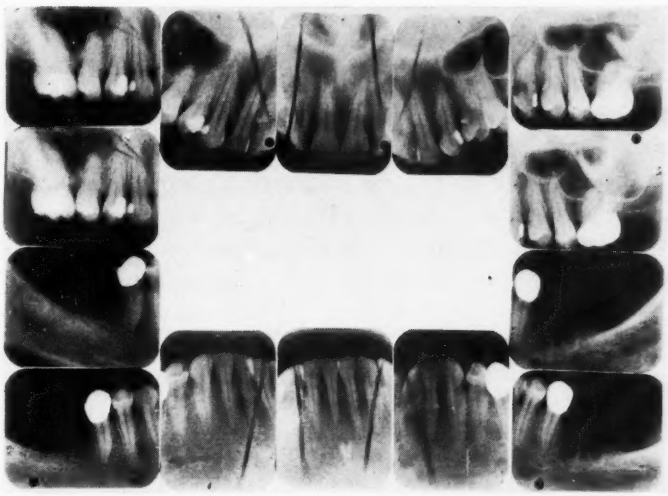


Fig. 2.—A severe loss of supporting bone in the edentulous areas in contrast to the excellent alveolar support of the remaining teeth. This indicates a good ability to maintain bone even in areas which have been in hyperfunction for a long period of time. This is the reverse of the situation shown in Fig. 1.

years—although some subjects were chosen who had posterior teeth missing for lesser periods, in an attempt to determine the time interval necessary for disuse to become significant.

The degree of physical loss of supporting structure was also considered in conjunction with an evaluation of roentgenograms of the patients to determine the amount of bone loss around remaining teeth (Figs. 1 and 2). A partially edentulous patient who exhibits excellent bone maintenance ability, as evidenced by a normal level of alveolar support in areas of prolonged occlusal overloading, should be able, with the aid of exercise therapy, to recondition atrophic edentulous areas to a normal supporting status and to maintain this support under functional occlusal loading for an extended period of time. The reconditioning period would be shorter for this type of patient than for a patient who shows a generalized loss of alveolar bone as well as severe loss of ridge bulk in edentulous areas.

The character of the remaining edentulous ridge was considered important in that narrow, spiny ridges, indicative of long disuse, with an excess of connective tissue covering were poor candidates for an immediate functional load. Periodontal disease, poor oral hygiene, and a history of less than good physical health were also factors considered when determining the choice of patients. The age, sex, attitude toward clinical requirements, and availability for roentgenographic and technical procedures were factors noted in the final selection of subjects.

MATERIALS

The materials used consisted of a Hydrocal cast of the arch at the completion of mouth preparation, activated acrylic resin for making occlusal templates to re-

tain the film holder and x-ray tube clamp, and ultra speed adult periapical x-ray films. Special equipment included two stainless steel film holders (right and left) and two aluminum step wedges of varying step thickness to give a range of radiopacity adequate for any ridge evaluation. Steps on the wedges were calibrated from 1 to 6 mm. and from 3 to 8 mm. in thickness. A 16 inch plastic x-ray tube was used in place of the regular short cone, and a ring clamp was used to attach this tube to the occlusal template (Figs. 3 and 4). A photographic analyzer* was utilized to make the radiopacity determination of the roentgenograms.

METHOD

On completion of all restorative and periodontal therapy and other mouth preparation procedures, an accurate impression of the remaining teeth and supporting structures was made and a stone cast poured in it. This master cast was duplicated in a refractory investment, and the partial denture framework was fabricated. The technique used in constructing metal and/or acrylic based appliances (Figs. 5, 6, and 7) has been described by Applegate.[1]

The acrylic resin occlusal template was constructed on the master cast. The film holder was positioned on the stone cast in such a way that the film would be parallel to the horizontal axis of the edentulous ridge (Figs. 8 and 10) and so that the reference point on the base of the film holder (Fig. 9) would be in an area well below the crest of the ridge and about 1 cm. posterior to the abutment tooth. It was felt that in this position, the radiopacity readings would be made in an area of the edentulous ridge at a point far enough removed from the abutment tooth not to be influenced by any functional stimulation which that tooth would provide to the supporting bone. The connecting ring clamp (Fig. 4) was then positioned so that the face of the ring would be parallel to the film and so that the center of this ring would be on a horizontal level with the indicator point on the film holder. Then the acrylic resin splint was poured so it engaged the tapered metal extension bar on both the ring clamp and the film holder. With the occlusal splint in proper position in the mouth (Figs. 4 and 10), the central ray from the x-ray tube would then be directed at the reference pointer on the film holder (Fig. 9). This type of splint and attachment allows repeated identical roentgenograms to be made of any desired area, thus following the periodic identical technique. With the aluminum step wedge in place on the film holder, its image would be produced on the processed film (Fig. 9), and from this known standard of radiopacity, that of the bone may be accurately determined as millimeters of aluminum.

ROENTGENOGRAPHIC PROCEDURE

The roentgenographic procedure consisted of readings made before insertion of the exercise prosthesis and at 2 week intervals after its insertion and exercise until the evaluations became constant. This procedure was continued whenever possible until the appliance was placed in function by the addition of teeth, following which time readings were made at 1 month intervals.

*Weston.

After the initial roentgenogram was made, the appliance was inserted in the patient's mouth and he was instructed about the exercise procedure. He performed this "biting" exercise by placing the tip of each forefinger on the exercise base just posterior to the abutment teeth. He was urged to bite on his fingers with a very light intermittent pressure and release action. In this way, it was hoped that an occlusal overload could be avoided during the early stages of the reconditioning process. This exercise was performed for short periods several times daily until evaluations became constant. Then teeth were placed on the appliance (Fig. 11).

The photographic analyzer was used in computing the results of the roentgenographic survey. The processed film (Fig. 9) was placed on the analyzer, and the radiopacity of the residual ridge in the area of the film holder indicator was noted. Readings were then made of the superimposed image of the step wedge, and simple mathematical interpolation was done to express the radiopacity of the test area in millimeters of aluminum.

Fig. 3.

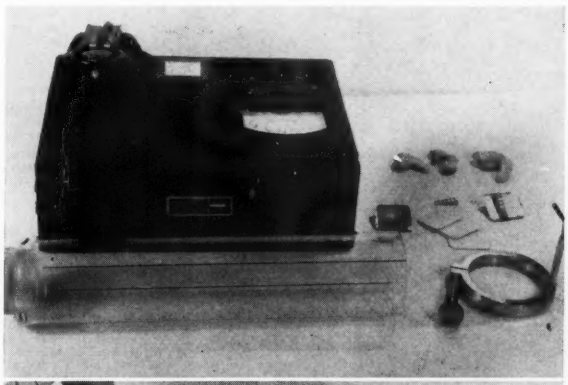


Fig. 4.

Fig. 3.—The materials used for the roentgenographic procedures: photographic analyzer, 16 inch plastic x-ray tube, acrylic resin occlusal splints, right and left stainless steel film holders, aluminum step wedges, periapical film, and ring clamp.

Fig. 4.—The complete radiographic attachment in position. This setup makes it possible to secure roentgenograms of the identical area at any time with the same angulation and target distance.

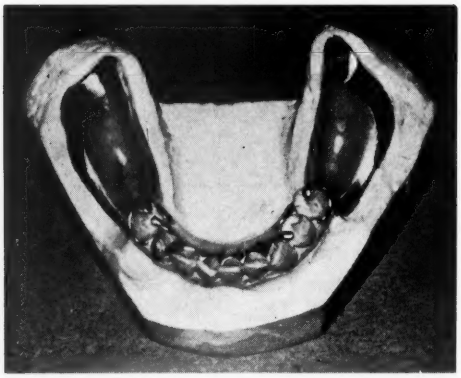


Fig. 5.—An exercise prosthesis. This type has cast metal bases which have been formed to cover the maximum area of the edentulous regions without impinging on moving structures at the borders. The supporting form of the ridges was recorded by a correctible wax impression. Activated acrylic resin covers the metal retention lugs to provide a smooth, comfortable surface during the period of exercise therapy. After the exercise therapy is complete, the acrylic resin filler is removed, and the teeth or cast occlusal surfaces may be attached with activated or heat-processed resin.

A.

B.

Fig. 6.—*A* and *B*, An exercise prosthesis having one metal and one resin base. This type of appliance requires that the correctible impression of the edentulous areas be made before the metal framework is waxed so the metal base may be cast to the supporting form of the edentulous area.[1] No appreciable difference in bone response was noted between the acrylic resin and metal bases in this study.

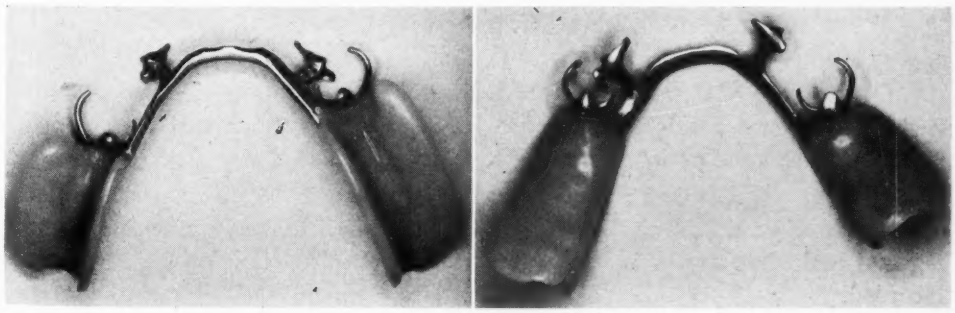
Subsequent periodic roentgenograms were processed in the same manner, and the values were compared with those of the initial exposure to determine any change in radiopacity. The values obtained were charted for each subject, and at the termination of treatment, a broken curve graph was made from these recorded values—the change in radiopacity on the ordinate, the time in weeks on the abscissa (Fig. 12). A star was inserted in the curve at the point at which the missing teeth were positioned and the appliance placed under functional load.

It should be noted that of the 20 subjects utilized in this survey, none showed a physical loss of supporting structure at the end of the exercise period. Of these, most have been under recall through the past 3 years and none have needed the appliance rebased.

GENERAL CURVE ANALYSIS

The character of the bone change curves as recorded from this study proved to be consistently similar in all respects. Variations occurred in the rapidity and magnitude of curve fluctuations, but the over-all pattern remained the same for each subject. The first sector of the curve was the immediate decrease in radiopacity as a result of pressure atrophy. This decline generally continued for from 3 to 5 weeks, with a leveling off or a gradual increase beginning to occur at this point. In most subjects, an increase in radiopacity began about the fifth week and continued quite uniformly, with full recovery being achieved by the eighth or tenth week. The increase in radiopacity is believed to be the effect of reorganization of the internal structure of the bone with the deposition of inorganic salts in the trabecular network as a result of work stimulation. Stoppage of the exercise stimulation caused a slight decline in radiopacity during the period just prior to restoration of function (Fig. 12). The initiation of a severe occlusal overload (supplied teeth in occlusal disharmony) will also cause a rapid decline in radiopacity.

To avoid any misunderstanding as to the true function of radiopacity analysis or bone density as it is presented in this study, we wish to state emphatically that



A. *B.*

Fig. 7.—*A* and *B*, An exercise appliance with acrylic resin bases. This type may be rebased, if necessary, at any time after therapy. It is also possible to convert these bases to metal by investment and burnout of the acrylic resin, then casting directly to the original framework. The occlusal surfaces may be cast with the base unit or they may be attached separately as in Figs. 5 and 6.

radiopacity was used only as a *yardstick* in determining bone change, not as a criterion for predicting the ability of any given area of supporting bone to withstand a functional occlusal load.

FACTORS INFLUENCING RESULTS

The two conditions which seemed to affect the results of the study most were the age of the subject and the length of time he had been edentulous. Other factors such as physical bulk of the ridge, sex, health status, oral hygiene, etc., did not appear to have a great influence on the final results.

The magnitude of change was directly associated with the length of time the patient had been edentulous. The length of time required to negotiate the change in radiopacity was a factor both of age and of the length of time he had been edentulous. An older subject who had been edentulous for many years showed a greater initial depletion in bone density, and the recovery rate was greatly reduced from that of a young subject or of one who had been edentulous for a much shorter time.

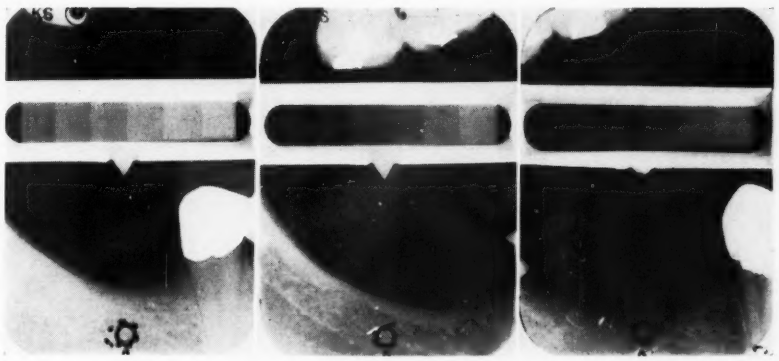
Fig. 8.—The film holder and an acrylic resin occlusal template are in position on the master cast. *A*, A plain acrylic resin template. *B*, An acrylic resin template which contains metal receptacles for receiving the film holder and ring clamp extensions (see Fig. 10).

Overloading of the supporting structures by too vigorous exercise or by occlusal interference against the exercise base caused a greater variation in radiopacity as well as a prolongation of the recovery period.

It seems reasonable that any condition which would cause a change in the body metabolism would also affect the results of such a study as this, therefore physical health status could play an important part in determining the final values recorded.

VARIATIONS AND INCONSISTENCIES

A good measure of the success or failure of such a study is dependent upon patient cooperation. Laxity on the part of the patient in carrying out exercise instructions will cause variation in the result.



A. *B.* *C.*

Fig. 9.—Processed films showing superimposed images of the aluminum step wedge. *A*, With the thick wedge (3 to 8 mm.). *B* and *C*, With the thin wedge (1 to 6 mm.). The reference indicator point (Λ) is at the bottom center of each film. The survey area of bone (○) is immediately off the point of the indicator.

Line voltage to the photographic analyzer should be carefully checked during recording procedures to ensure accurate readings. Fluctuation in voltage will cause significant error in the values obtained.

Exposure and processing of the radiographic film should be carefully controlled in an effort to secure a density value that falls within the middle scale of the photographic analyzer. Greater density values cannot be accurately determined on this instrument since fractional values must be estimated as one approaches the upper limits of the scale.

Occlusal interference against the exercise base should be avoided, particularly the impingement of an opposing extruded tooth which will cause a deviation from

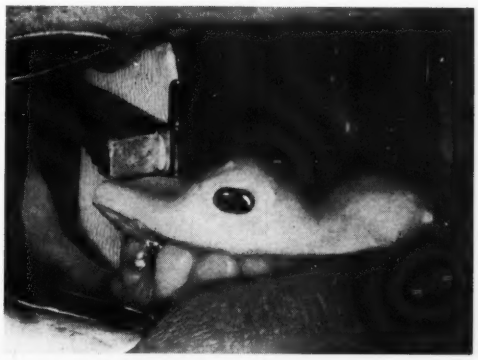


Fig. 10.—The template with the film holder and step wedge is in position in the mouth. The film is parallel to the edentulous ridge and deep enough toward the floor of the mouth to place the indicator point in its proper position relative to the abutment tooth and the crest of the ridge. The impression technique for making the master cast is altered to depress the structures in the floor of the mouth in the edentulous areas to permit the placement of the film holder. The occlusal template is trimmed to a knife edge at the occlusal stops to permit easy inspection of its seating in the mouth.

the normal pattern of bone change. If such an occlusal contact with the exercise base is possible, it would result in prolonged pressure. It is important that the stimuli induced be not only light but that they be intermittent. Short, rapid, and light pressures, as from biting on a finger placed on the base close to the right and left abutments, have proved to be a good way of providing the exercise.

SUMMARY

Consistent with one of the basic principles of partial denture service, that of preserving the remaining oral structures while restoring function, a practical technique of exercise therapy has been presented whereby available supporting structures, depleted through prolonged disuse, can be reconditioned and function of missing teeth can be restored by prosthetic means. This method of treatment is not meant to be used for every patient who requires a free end partial denture but for those selected patients with conditions which demand something more than the ordinary prosthetic service. This type of program is a burden neither to the dentist nor to the patient, and patient cooperation is generally excellent once he knows why such a plan is being proposed.

CONCLUSIONS

1. Exercise stimulation of subbasal structures is a practical and desirable part of partial denture treatment for patients in whom the ability of these structures immediately to give adequate support without loss of physical bulk has declined because of prolonged disuse.

2. The type of base material seems not to play a significant part in the results of exercise treatment of supporting structures of the mandible.

3. Exercise stimulation for a period of 12 weeks is usually adequate for reconditioning the most severe cases of disuse atrophy. Under average circumstances, a period of 8 to 10 weeks of stimulation therapy is sufficient.

4. Edentulous areas in the mandible usually do not undergo severe disuse atrophy during a period of less than 5 years.

Fig. 11.—The teeth were added to this partial denture after the exercise therapy. It is extremely important that the occlusion be balanced perfectly so that masticatory function will not result in an overload. The size of the occlusal table should be reduced when the base area is inadequate or when the patient's ability to maintain normal bone support is decreased.

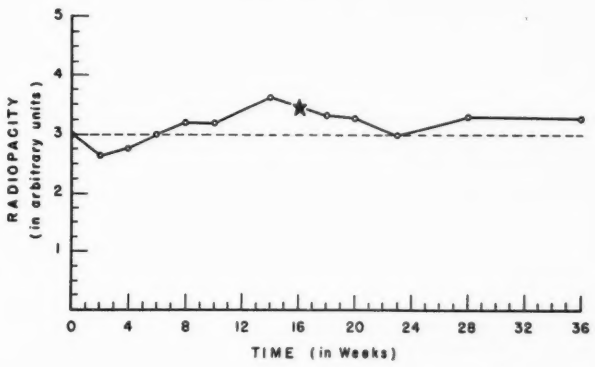


Fig. 12.—A typical bone change curve. The broken line represents the initial radiopacity value for this subject. Tabulation of values through a 14 week period shows a sharp initial decline in radiopacity followed by a gradual increase in bone density to a level exceeding the initial value. The star in the curve at 16 weeks represents the point at which functional occlusion was restored. At 14 weeks, the appliance was taken from the patient to attach the occlusal surfaces. This accounts for a decline in radiopacity resulting from cessation of exercise stimulation. A continuing decline in radiopacity follows the restoration of function but to a lesser degree than was shown at the beginning of exercise. Subsequent recovery and leveling off at a radiopacity value in excess of that at the beginning of treatment indicate an excellent response to exercise therapy and the restoration of a functional occlusion which is within the tolerance of the tissue of this subject.

5. If bone reorganization is accomplished by frequently induced light, intermittent stimuli, the supporting structures can be prepared for the return of occlusal function within the limits of individual tolerance. Later rebasing is usually unnecessary.

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REMOVABLE PARTIAL UPPER AND COMPLETE LOWER DENTURES

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FIVE TO SEVEN NATURAL TEETH in good condition in the upper dental arch with a completely edentulous lower dental arch present a serious problem in diagnosis. The diagnosis is usually complicated because of a poorly fitting lower denture and an upper removable partial denture. This condition usually results in a severely resorbed lower residual ridge.

The personalities of patients in this situation can be seriously affected by what they consider the hopeless state of their oral health. They feel that they cannot chew food properly, their mouths are uncomfortable and traumatized, the mandible can never seem to find a firmly defined terminal position, and they believe that their physical appearance is marred beyond hope of remedy.

FUNDAMENTAL SPECIFICATIONS OF DENTURE CONSTRUCTION

The fundamental specifications essential to the construction of properly functioning complete dentures apply equally to the successful construction of removable partial upper and complete lower dentures. These specifications are (1) understanding and proper execution of the requirements inherent in a successful complete lower denture impression technique, (2) a correct registration and recording of centric relation at an accurately determined vertical dimension of occlusion, and (3) a correctly formulated scheme of occlusion.

LOWER DENTURE IMPRESSION REQUIREMENTS

The objectives of the complete lower denture impression technique are adequate protection of the underlying residual ridge, stability of the denture in function, and provision for an adequate denture base to support the stresses of masticatory function.

Protection for the underlying ridge is instituted by a mucostatic impression technique. This technique affords a negative record of the primary and secondary stress-bearing areas when the tissues are at rest.

Stability of the lower denture is largely accomplished by a correct evaluation of border lengths to the adjacent tissues in function. The denture border is a dynamic, functional entity because of its intimate relationship with functional tissues and organs (Fig. 1). The accurate and complete development of the border

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contours must be accomplished with a full awareness of the functional capabilities of the structures involved (Figs. 2 and 3).

STRUCTURES AFFECTING FORM OF LOWER DENTURE BORDER

Border molding of the labial and buccal flanges creates a moderate but definite placement of the tissues that are in contact with the border of the denture.[1] Labially, the orbicularis oris and the triangularis muscles are involved at the corner of the mouth (Fig. 3). Buccally, the buccinator muscle principally and a part of the anterior border of the masseter muscle affect the form of the denture.[2]

The triangularis muscle is a broad, strong muscle which attaches to the mandible just below the buccal frenum and inserts into the skin. This muscle causes a slight upward undulation of the flexure line of the buccal mucosa in the region of the lower cuspids (Fig. 2). However, this gentle appearing curvature is a strong displacing force exerted against the lower denture border and is a definite factor in border molding the labial flange of the lower denture (Fig. 1).

The buccinator muscle forms the lining of the cheek and presents the longest extent of surface which contacts the border of the buccal flange of the lower denture. The fibers of this muscle run anteroposteriorly and, for this reason, permit some lateral encroachment by the buccal flange of the denture.[3]

The distobuccal curvature of the lower denture border encounters a displacing force from the anterior border of the masseter muscle.[1] This muscle is inserted at the angle and lower border of the body of the mandible and extends upward and forward to its origin on the lateral aspect and inferior border of the zygomatic arch.[4] The distobuccal border of the lower denture must be carefully border molded to allow for the upward and forward pull of the masseter muscle during its contraction.

The tonus of the muscles in the buccal and labial vestibule is often in flaccid condition. This condition is favorable to stability of the lower denture because the musculature adjacent to the denture border offers a relatively weak displacing force to the denture in function. Thus, the primary bearing area of the buccal shelf can be extended laterally to afford a broader base of support for the lower denture in mastication and a greater resistance to displacement resulting from masticatory forces.

The contour of the border of the lingual flange is determined by the functional position of the mylohyoid muscle, which is controlled by movements of the tongue. Protrusive or lateral movements of the tongue will raise the mylohyoid muscle.[2] Tongue protrusion anteriorly or laterally also raises the sublingual gland. This gland causes the anterior part of the lingual flange of the lower denture to be considerably shorter than the posterior part. It is particularly desirable to adjust the lingual flanges of the lower impression to extreme lateral tongue movements since every added factor contributing to lower denture stability is critical (Fig. 4).

Elevation of the tip of the tongue in the direction of the incisive papilla frequently reveals a prominent and strongly defined lingual frenum (Fig. 5) for which adequate relief must be developed in the extreme anterior part of the lingual flange of the lower denture.[3] Tongue movements which are not compensated for by correct border relief result in displacing forces.

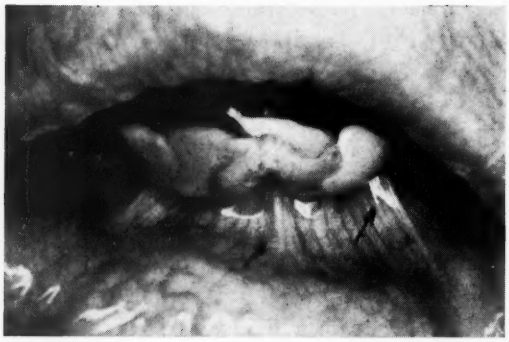

Fig. 1.—A completed lower impression in the mouth demonstrates adequate functional relief for the labial and buccal frenula.

Fig. 2.

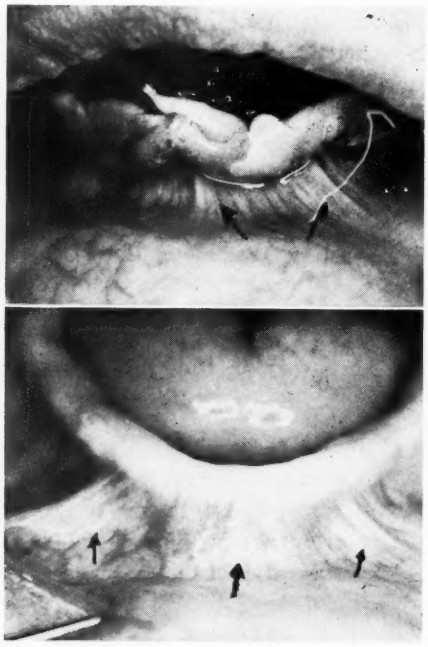

Fig. 3.

Fig. 2.—A completed lower impression in the mouth demonstrates functional relief for the left buccal frenum. Note that the right buccal frenum appears as hardly more than a gentle undulation, yet it exerts a strong displacing force if the buccal notch is inadequate.

Fig. 3.—Strong buccal and labial frenula are present when the cheeks are retracted laterally. The labial frenum is a tab of mucosa which acts as an anchor point for the orbicularis oris muscle.

IMPORTANCE OF CENTRIC RELATION

The terminal position of the masticatory stroke is centric relation, the most retruded and unstrained position of the mandible.[5] The greatest chewing force is exerted in this position. Therefore, an improperly recorded centric relation results

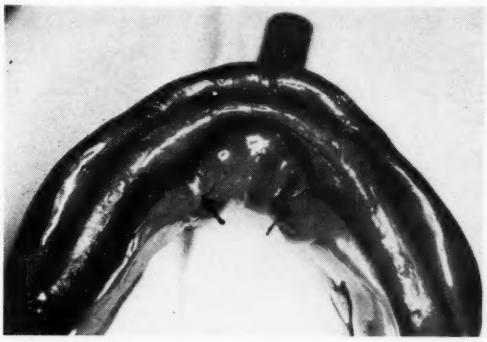

Fig. 4.—The lingual flanges of the lower impression are border molded to extreme tongue movements. Note the supplemental attachment of the mylohyoid muscle in the second bicuspid region as indicated by the deep clefts on both sides.

in deflective occlusal contacts as the patient attempts to terminate the chewing cycle. These deflective contacts cause trauma and resorption of the underlying ridge, create a displacing force against the lower denture, and can cause harmful emotional effects. This is just as true of dentures with a nonanatomic occlusion as it is of those in which anatomic teeth are used.

The medium for registering centric relation is just as important as the registration procedure itself. A substance offering the least possible resistance to closing pressures is essential, since the occlusion is dependent upon the orientation of upper and lower casts in the horizontal as well as the vertical plane.[1]

RECORDING CENTRIC RELATION

An anterior stop at the desired vertical dimension of occlusion combined with a posterior record in plaster or Aluwax reduces displacement of underlying tissues to a minimum during the recording of centric relation (Fig. 6).[1] An intraoral or extraoral tracer mounted with a central bearing point is used when conditions are favorable. A high degree of accuracy is obtained when the opposing bases are held apart by a centrally placed intraoral bearing point and are locked in centric relation by an interposed plaster record.

ACCURATELY CONCEIVED OCCLUSION

The third and equally vital factor is an occlusion accurately conceived and formulated to the needs of this specific situation. A complete lower denture resting upon a ridge with severe bone resorption must resist the displacing forces of a partial complement of natural upper teeth. Therefore, any means by which these forces can be minimized must be utilized.

A posterior occlusion employing nonanatomic teeth aids in the stability and greatly reduces the displacing forces encountered in mandibular movements during mastication. This form of posterior occlusion is equally desirable in minimizing the displacing forces of tooth contacts from other jaw movements.*

*I. R. Hardy: Personal communication.

The lower anterior teeth must be arranged for esthetic appearance and to meet the requirements of a nonanatomic posterior occlusion after the centric relation record has been transferred to the articulator (Figs. 6 and 8). Thus, there must be no vertical overlap of the anterior teeth.

A plane of occlusion is constructed on the lower base beginning at the height of the cusp of the lower left cuspid and extending distally parallel with the crest of the lower ridge (Fig. 7). The distal extremity of the occlusal plane must be no higher than the center of the retromolar pad.[6]

A line drawn along the side of the cast indicates the inclination of the crest of the lower ridge. A vertical line, extended onto the side of the occlusion rim, indicates the point of distal termination of the posterior occlusion (Fig. 7). This vertical line indicates the point at which the lower ridge slopes sharply upward toward the retromolar pad, and no posterior teeth should be set upon this incline.*

Fig. 5.—The lingual frenum becomes evident when the tip of the tongue is elevated.

The upper artificial posterior teeth are set into the upper occlusion rim in continuity with the natural teeth and in proper relationship to the plane formed by the lower occlusion rim (Fig. 7). They are centered over the crest of the lower ridge. The posterior occlusion is completed by arranging the lower posterior teeth to the upper posterior teeth (Fig. 8).

The presence of one or more natural upper posterior teeth not in harmony with the plane of posterior occlusion need not offer an insurmountable obstacle to this type of restoration. Onlays can be built in conjunction with the upper removable partial denture (Fig. 9), and other interferences can often be corrected by full crowns.

SHAPE OF THE POLISHED SURFACES

The shape and contour of the polished surfaces contribute greatly to the stability of the lower denture. The buccal flanges should be concave on their outer surfaces to allow the cheeks to lie against them. The lingual flanges should slope downward and outward with no concavity to allow the tongue to spread laterally. How-

*I. R. Hardy: Personal communication.

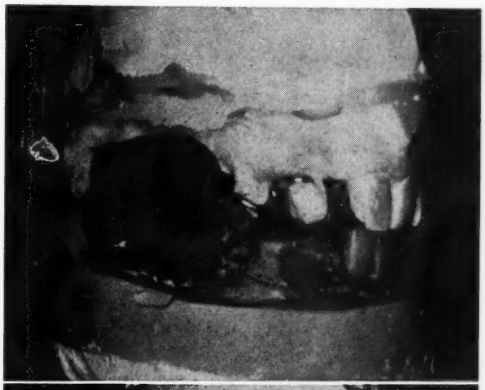

Fig. 6.

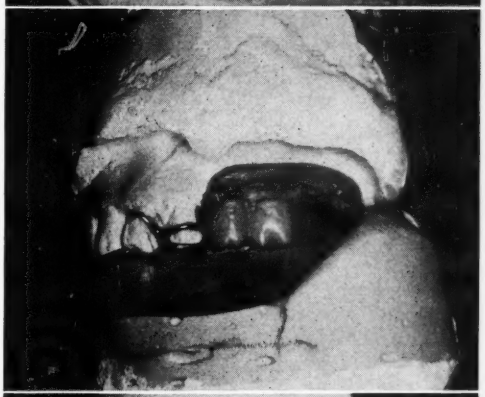

Fig. 7.

Fig. 8.

Fig. 6.—The lower anterior teeth are arranged after centric relation has been recorded. Soft wax is used posteriorly to register centric relation.

Fig. 7.—The height of the occlusal plane is developed on the lower occlusion rim. Note that the plane is parallel with a pencil line on the side of the cast which in turn is parallel with the crest of the ridge. The vertical line on the side of the cast indicates the distal termination of the posterior teeth.

Fig. 8.—The posterior occlusion is completed on the left side. Note that the natural first bicuspid is not in occlusion.

ever, the anterior part of the lingual flange should demonstrate a gently formed concavity for the tongue to gain additional stability.

Fig. 9.—The completed dentures are in the mouth. Note the acrylic resin overlay restoring the occlusion of the natural upper left first bicuspid.

SUMMARY

The concept of the removable partial upper and complete lower denture has been discussed. The requirements for success of such dentures are (1) a meticulously developed lower denture impression, (2) accurately registered and recorded centric relation at the correct vertical dimension of occlusion, and (3) carefully formulated occlusion.

The musculature related to the lower denture border, the fundamental needs attendant on an accurate centric relation record, and the method and particulars related to the posterior occlusion have been described.

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NUMERICAL SYSTEM OF CLASP DESIGN

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THIS ARTICLE DESCRIBES an approach to the clasp problem based on a mathematical analysis.[1] Whatever the complications of the original analysis, this approach can be adapted for prosthetics in an extremely simple form.

Certain terms used in clasp design such as strength and retention require precise definitions if they are to be used in the discussion of clasp problems. These terms can be defined so that they not only correspond with a common sense interpretation but in addition possess certain valuable properties. Thus, the strength of a clasp is equal to the sum of the strengths of its components.

This additive property is an essential characteristic of the system to be described. Moreover, the system offers a simple means of measuring clasp performance and, in particular, the quality of the design and the material.

Quality is important and constitutes the main subject of this article. Like strength, the quality of a finished clasp, i.e., its potential performance, can be assessed as the sum of the qualities of its components.

CLINICAL ASPECTS OF CLASP DESIGN

The stresses in the material must not exceed a certain critical value if the clasp is to function without danger of deformation. This critical value is often expressed in terms of the safety factor of the structure. However, it is convenient to define a new term, the margin of safety or reserve (R_s) of the clasp. A clasp has no reserve or margin of safety when the material is about to suffer permanent deformation (Table I). Negative values of R_s imply failure, and the scale is such that a reserve of 1 unit corresponds to a safety factor of approximately 2. Such a factor of safety appears to be both necessary and adequate. Therefore, the first requirement of this system is that *the reserve must not be negative.* For an adequate reserve, $R_s = 1$.

Retention depends on friction and the force exerted by the clasp. However, a knowledge of the exact value of retention in terms of grams or pounds is neither possible nor of practical importance. It is sufficient that retention should be expressed on some scale which indicates whether it is too low, too high, or of the right order. Therefore, retention (R_t) is defined in terms of the force exerted by the clasp so that a negative value implies inadequate retention (Table I). However, unlike the reserve, the zero point of retention is somewhat arbitrary, corresponding to a retentive force of approximately 35 Gm. or 1.5 ounces. The coefficient of friction between tooth and metal is approximately 0.2, but it is higher for acrylic resin.[2]

TABLE I. DEFINITIONS FOR UNIFORM, UNTAPERED CLASP ARMS

FACTOR	DEFINITION	
R_s	4 log (safety factor) = 4 log $\frac{P}{p}$	
R_t	3 log F + 2.25	
Q_c	log $\frac{K}{k^4}$ + 1.75 + log r + log c	(clasp)
Q_m	4 log P − 3 log E + 6	(material)
Q_t	5 log s − 3 log u − 7	(tooth)
S_c	4 log $\frac{K}{k}$ + 5 + 4 log r + 12 log t	(clasp)
S_m	4 log P − 6	(material)
S_t	4 − 4 log R	(tooth)
c	Taper factor	
E	Modulus of elasticity in Kg. per sq. mm.	
F	Force at tip of clasp arm in Kg.	
K,k	Cross-section shape factors	
p	Maximum stress in the material in Kg. per sq. mm.	
P	Proportional limit in Kg. per sq. mm.	
Q	Quality = $R_s + \frac{1}{3}R_t = Q_c + Q_m + Q_t$	
r	Width to thickness ratio of cross section	
R	Effective tooth radius in mm.	
R_s	Reserve = $\frac{1}{3}(4Q - S)$	
R_t	Retention = $S - Q = 3(Q - R_s)$	
S	Strength = $Q + R_t = R_s + \frac{4}{3}R_t = 4Q - 3R_s = S_c + S_m + S_t$	
s	Effective length of clasp arm in mm.	
t	Thickness of clasp arm in mm.	
u	Deflection of clasp tip or depth of undercut in mm.	

It is difficult to decide what should constitute adequate retention, but a retentive force per tooth of 75 Gm. or 3 ounces appears reasonable and corresponds to $R_t = 1$. As an upper limit, $R_t = 3$ is probably excessive, for it corresponds to a force of nearly 2 Kg. or 4 pounds on the tooth. *The retention must not be negative.* For adequate retention, $R_t = 1$.

The two R factors, reserve and retention, offer a clinical assessment of clasp behavior. However, their chief merit emerges when they appear in combination. Two combinations are of particular importance, one assessing performance (Q), the other the strength (S) of the clasp.*

Q is the quality of the over-all design and is the most important of all factors of clasp design. Its definition is $Q = R_s + \frac{1}{3}R_t$.

S is the strength of the clasp and serves principally to calculate the correct clasp thickness. The formula is $S = Q + R_t$.

If any two of these four quantities are known, the other two can be calculated (Table I). For a clasp to have adequate values of both reserve and retention ($R_s = 1$ and $R_t = 1$), the quality should be no less than 1.3. Only certain materials and designs measure up to this requirement.

*The four symbols R_s, R_t, Q, and S differ from those used in the mathematical analysis.[1]

LABORATORY ASPECTS OF CLASP DESIGN

The clasp is ultimately designed in the laboratory. Q and S are important because they can each be broken down into three factors corresponding to the three laboratory elements of the problem—the clasp itself, the material, and the tooth. Moreover, these three elements combine by simple addition, and each is to a first approximation independent of the other two. $Q = Q_c + Q_m + Q_t$, and $S = S_c + S_m + S_t$. The subscripts c, m, and t stand for clasp, material, and tooth.

The six Q and S factors can be calculated theoretically and are fully defined in Table I. All but one factor are fixed by the design, so that when the clasp is completed, five factors remain characteristic of it throughout its existence. However, the sixth factor, Q_t, depends on the deflection of the clasp. It is infinitely large when the clasp is at rest but falls rapidly as the tip of the clasp is deflected, reaching its lowest value when the deflection of the clasp corresponds to the depth of the undercut. This specific value of Q_t determines performance and is dependent on the tooth. Only by using small undercuts can reasonable values of Q_t be achieved (see Table IV).

S should be high to gain good retention with an adequate reserve since the retention is calculated from the difference between S and Q ($R_t = S - Q$, by definition). S can be made large simply by making the clasp thicker (S_c in Table V). However, S may not exceed $4Q$, since $S = 4Q - 3R_s$ from Table I and R_s must be positive. Q cannot be increased in this manner because there is no way to increase Q indefinitely, and it is ultimately Q which limits S and clasp behavior. Q is the ultimate controlling factor in retention. An increase in Q of 1 unit permits a tenfold increase in retention. Q is a criterion of quality to which Q_c, Q_m, and Q_t contribute. Therefore, these three factors are quality factors for the clasp material, and tooth, respectively.

S, unlike Q, is a constant characteristic of the clasp alone since S_c, S_m, and S_t are all fixed by the clasp. If the clasp arm is deflected to the point of failure so that the reserve is reduced to zero, S is equal to $4/3\ R_t$ ($S = R_s + 4/3\ R_t$ from Table I, and R_s is zero). This value of the retention measures the maximum force which can be exerted on the clasp. Therefore, S measures the strength of the clasp *and its ability to withstand rough handling.*

TABLE II. APPROXIMATE VALUES OF Q_c FOR UNIFORM, UNTAPERED CLASP ARMS

SHAPE	WIDTH TO THICKNESS RATIO	Q_c
Round	1.0	0.4
Half oval	1.0	0.7
	1.5	0.9
	2.0*	1.0
	2.5	1.1
	3.0	1.2

*Half round.

A clasp should be designed to have the highest possible value of Q, and the thickness should give a suitable value of S to provide good retention with adequate reserve. A higher value of S improves retention but does so at the expense of a low margin of safety.

QUALITY FACTORS

Typical values for the three quality factors, Q_c, Q_m, and Q_t, are listed in Tables II, III, and IV. These tables are limited to simple, uniform, untapered clasp arms. Bar clasp arms and the effects of tapering and torsion have been reported previously.[1]

TABLE III. VALUES OF Q_m AND S_m FOR A NUMBER OF CLASP MATERIALS

MATERIAL	Q_m	S_m
Aluminum (sand cast; 5 per cent magnesium, 0.5 per cent manganese)	−1.9	−2.4
Nickel chromium alloy (nickel, molybdenum, chromium)	−0.9	0
Chrome cobalt alloys		
1	−0.8	0.1
2	−0.2	1.0
3	0.5	0.8
Cast white gold		
Annealed	0	−0.1
Hardened	1.0	1.0
Stainless steel (cold rolled)	0.4	1.3
Cast yellow gold		
1		
Annealed	0	−0.1
Hardened	0.9	0.9
2		
Annealed	−0.2	−0.4
Hardened	1.1	1.0
Acrylic resin	1.2	−3.4
Wrought yellow gold		
Annealed	1.0	1.2
Hardened	1.6	1.8

The figures are based on manufacturers' claims and calculated from the definitions in Table I. Alternative definitions for specifications in pounds per square inch are $Q_m = 4 \log P - 3 \log E + 2.85$ and $S_m = 4(\log P - 4.653)$.

The quality of the clasp design is measured by Q_c (Table II). Both tapering and the shape of the cross section of the clasp make contributions, but the former to a smaller extent than might be supposed. Tapering, under ideal circumstances, improves Q_c by 0.4 units. However, even the most careful technique would not normally add more than 0.3 units for cast clasps and 0.2 units for wrought wire. By contrast, replacing round wire by half round wire adds 0.6 units to Q_c. Even more can be gained by using half oval wire of a greater width to thickness ratio. Therefore, shape is more important than tapering, and half round wire is greatly superior to round wire. Despite this fact, the importance of tapering should not be underestimated, for the addition of 0.2 units to Q can make a decisive contribution to the success of the clasp.

TABLE IV. TYPICAL VALUES OF Q_t AS A FUNCTION OF CLASP LENGTH AND UNDERCUT

CLASP LENGTH (MM.)	0.005 (IN.)	0.0075 (IN.)	0.010 (IN.)	0.015 (IN.)	0.020 (IN.)
Premolar					
8	0.2	−0.3	−0.7	−1.2	−1.6
9	0.5	0	−0.4	−0.9	−1.3
10	0.7	0.2	−0.2	−0.7	−1.1
Molar					
13	1.3	0.8	0.4	−0.1	−0.5
14	1.4	0.9	0.5	0	−0.4
15	1.6	1.1	0.7	0.2	−0.2

Some values of Q_t are listed in Table IV. These values depend by definition on the length of the clasp arm and the undercut, both of which are determined by the tooth. A value greater than zero for a premolar or greater than 1 for a molar is difficult to achieve. Small undercuts and long clasp arms favor retention by improving Q_t.

The choice of material depends on Q_m. Some typical values are listed in Table III. The dividing line between good and poor clasp materials can be established by examining performance figures in a typical problem. Clasping a premolar offers a good example since requirements are generally severe. Q_t is unlikely to be greater than zero under these conditions (Table IV). With uniform half round wire for which $Q_c = 1$ (Table II) on a premolar where $Q_t = 0$, the value of Q of the clasp can only reach the desirable minimum of 1.3 units by making Q_m not less than 0.3. Allowing for an improvement in Q_c of 0.3 units by careful clasp tapering,

TABLE V. CLASP THICKNESS (MILLIMETERS) IN TERMS OF S_e FOR UNIFORM, UNTAPERED ARMS OF ROUND AND HALF OVAL CROSS SECTIONS, WITH FOUR WIDTH TO THICKNESS RATIOS

S_e	ROUND	HALF OVAL			
		1.5	2.0*	2.5	3.0
−2.0	0.57	0.45	0.41	0.38	0.36
−1.5	0.62	0.50	0.45	0.42	0.39
−1.0	0.69	0.55	0.50	0.46	0.43
−0.5	0.76	0.60	0.55	0.51	0.48
0	0.83	0.66	0.60	0.56	0.53
0.5	0.91	0.73	0.66	0.61	0.58
1.0	1.00	0.80	0.73	0.67	0.64
1.5	1.11	0.88	0.80	0.74	0.70
2.0	1.22	0.97	0.88	0.82	0.77
2.5	1.34	1.07	0.97	0.90	0.85
3.0	1.48	1.17	1.07	0.99	0.93

*I.e., half round.

TABLE VI. APPROXIMATE VALUES OF S_t FOR A UNIFORM, UNTAPERED CLASP ARM, IN TERMS OF TOOTH RADIUS

TOOTH	TOOTH RADIUS (MM.)	S_t
Premolar		
Small	4.0	1.6
Average	4.5	1.4
Large	5.0	1.2
Molar		
Small	6.0	0.9
Average	6.5	0.7
Large	7.0	0.6

one arrives at the conclusion that Q_m must not be negative. *A negative value of Q_m implies an unsatisfactory clasp material.*

Since other factors enter into this problem, a positive value of Q_m does not necessarily ensure a satisfactory clasp material. This is illustrated by white and yellow casting golds. In theory, these golds should perform equally well, but in practice, white golds appear to be more susceptible to failure. However, in general, the Q_m rating accords with experience (Table III). Most chrome-cobalt alloys are poor, whereas stainless steel is reasonably good and wrought yellow gold is excellent. Acrylic resin is perhaps the most interesting of all the materials listed. Although resin is much weaker than the other materials (compare their strength values, S_m), it has a relatively high Q_m value and has been used satisfactorily as a clasp material.[3]

STRENGTH FACTORS

The S factors are listed in Tables III (S_m), V (S_c), and VI (S_t). They allow clasp thickness to be calculated to give satisfactory values for reserve and retention.

Wrought stainless steel wire is a common clasp material, and it is important to know what gauge should be used. Table III gives stainless steel Q_m of 0.4. With half round wire for which $Q_c = 1$ on a premolar ($Q_t = 0$), the quality of the over-all design adds up to $Q = 1 + 0.4 + 0 = 1.4$. However, with round wire ($Q_c = 0.4$), the quality would only have been 0.8 units. Therefore, stainless steel is an adequate clasp material in the form of half round wire but not as round wire. This has been borne out by experience.

To ensure an adequate reserve of 1 unit, S should be equal to 2.6 ($S = 4Q - 3R_s$ from Table I). With $S_m = 1.3$ from Table III and $S_t = 1.4$ for the average premolar from Table VI, S_c must be -0.1 for the sum to add up to 2.6. $S_c = -0.1$ corresponds to a half round thickness of 0.6 mm. (Table V).

Half round stainless steel wire 0.75 mm. thick (gauge 0.057 by 0.031 inch) is commonly used for clasps. Calculations show that this gauge is suitable for molars but gives too much retention on premolars with a low margin of safety ($R_t = 2.5$, $R_s = 0.6$). Only if the wire is tapered will it prove satisfactory, for the value of Q is raised and the thickness incidentally reduced.

FAULTY DESIGN

A half round stainless steel wire 0.75 mm. thick on a premolar gives a reserve value of 0.6 units. This might appear adequate at first. However, it is not enough for the following reasons. An error in Q results in an error in reserve one-third greater. An undercut too deep by only 0.0025 inch (0.0625 mm.) could use up all 0.6 units of this reserve. Even though tooth mobility may sometimes compensate, it is easy to find other sources of uncertainty, not only in Q_c or Q_t but also in Q_m. These sources of error make a reserve of 1 whole unit amply justified.

Many clasps in practice function too near their limit, and a proportion of them are bound to fail. The main difference between a wrought and a cast clasp is that while the former will bend, the later will frequently break. The fault lies in not allowing for a sufficient margin of safety in the original design. Liberties with stainless steel cannot be taken in ways that are possible with wrought gold. The Q_m value of cast materials is inherently less reliable than that of wrought materials, and there are few alloys with Q_m sufficiently high to override the effects of faulty design.

SUMMARY

Many terms necessary in clasp construction such as strength and retention can be expressed numerically. However, by suitable choice of definitions, they can also be made additive so that calculations are reduced to the simplest procedures of addition and subtraction. The strength of the clasp, for example, can be assessed as the sum of contributions from three components—the clasp, the material, and the tooth. The quality or value of Q of the clasp measures clasp performance and, like strength, is the sum of three quality components, from the clasp, the material, and the tooth.

This method gives a means of assessing not merely the over-all performance but, more especially, the relative merits of shape and tapering in clasp design and the suitability of different materials for clasp work.

The Q value of the material, Q_m, can be calculated from published data and offers a framework for future research on clasp materials.

The writer would like to thank Mr. A. G. Allen and Mr. S. F. Fish of the Dental School of the London Hospital Medical College, under whom this work was initiated.

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FIXED PARTIAL DENTURES

MODIFIED ABUTMENTS FOR REMOVABLE AND FIXED PROSTHODONTICS

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A PROBLEM ENCOUNTERED when constructing a partial denture is an abutment tooth with the loss of gingival tissue, exposing cementum. The loss of tissue may be due to gingival recession, trauma, senile atrophy, or a gingivectomy. However, regardless of the cause, the cervical part of the tooth is more susceptible to caries with the close proximity of a tang (minor connector) and a partial denture base.

There are times in fixed partial prosthodontics when the usual type of abutments cannot be used because of existing fillings, caries, or the size and shape of the tooth.

In this article, several procedures will be described by which these conditions can be corrected with modified types of restorations.

MODIFIED SLICE-LOCK PREPARATION

The conventional slice-lock inlay preparation is modified so the slice is carried cervically onto the distal surface of the cementum to the level of the gingivae.

The slice-lock preparation limits the choice of the tooth on which it can be used. Occlusal and proximal caries penetration may not extend beyond the dentoenamel junction.

The proximal slice is made with a flat diamond disk and carried onto the surface of the cementum to the level of the gingivae, and the usual occlusal dovetail retention is used (Fig. 1). After the proximal slice has been made, the lock or keyway is cut into the proximal surface with a No. 701 tapered fissure bur. The slot should extend from the pulpal floor cervically about 4 mm. along the axial wall. The shape of the lock or keyway can be either round or oval.

When the slice is carried to the level of the gingivae, the buccolingual width of the inlay will be sufficient so the proximal end of a partial denture base or a tang for a clasp with an occlusal rest will contact the inlay and not the surface of the tooth.

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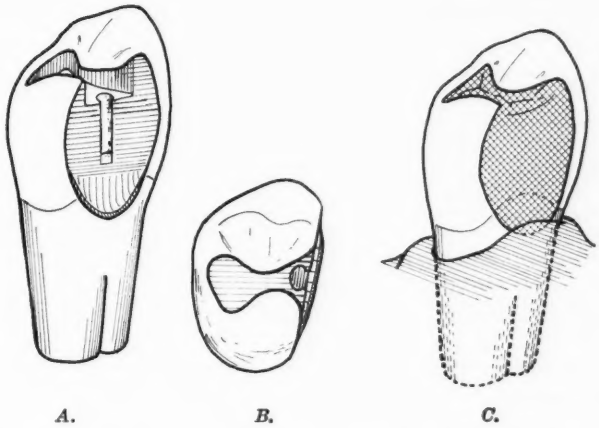


Fig. 1.—*A*, The slice on the proximal surface is carried onto the surface of the cementum. *B*, The occlusal surface has a dovetail and proximal lock. *C*, The finished restoration extends under the free gingivae.

MODIFIED SLICE-BOX PREPARATION

The conventional class II inlay preparation is modified so the slice is carried cervically onto the distal surface of the cementum to the level of the gingivae.

In the slice-box preparation, a filling or caries may exist in a tooth beyond the dentoenamel junction. A normal class II preparation is made after removing all existing filling material or carious dentin (Fig. 2). A slice is made on the distal surface with a flat diamond disk. This proximal slice is carried cervically onto the surface of the cementum to the level of the gingivae.

When the slice is carried to the level of the gingivae, the buccolingual width of the inlay will be sufficient that the proximal end of a partial denture base or a tang for a clasp with an occlusal rest will contact the inlay and not the surface of the tooth.

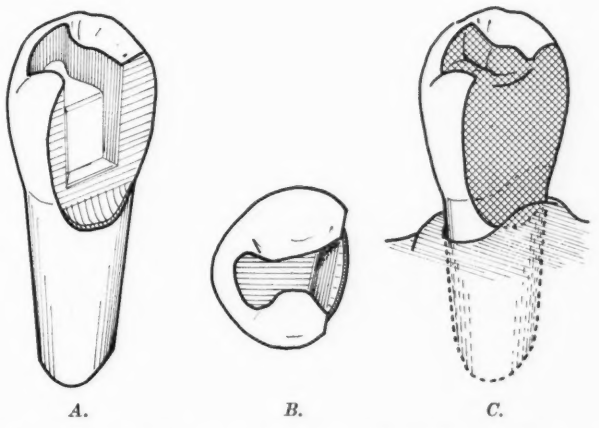


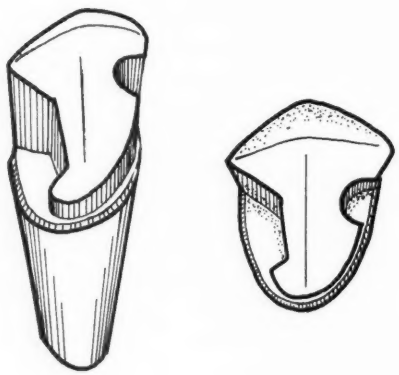
Fig. 2.—*A*, The proximal surface of a slice-box preparation has the slice carried onto the surface of the cementum. *B*, The occlusal surface has a dovetail and proximal box. *C*, The restoration extends under the free gingivae.

The slice-box preparations may be used for abutments for precision attachment partial dentures. However, they should not be used for this purpose without including the opposite proximal surface of the tooth involved. The pulpal floor must be lowered and the buccolingual width of the occlusal part of the preparation must be widened, each about 1 mm., for additional strength.

MODIFIED THREE-QUARTER CROWN PREPARATION WITH A PROXIMAL BOX

In many three-quarter crown preparations on anterior teeth, it is difficult to get proximal grooves in sound tooth structure because of existing fillings. The preparation and the restoration are failures if the proximal grooves are in existing filling material or cement.

One or two of the proximal surfaces of an anterior tooth may have an existing filling, which is removed entirely. The proximal slices should be cut so that they taper toward the lingual cingulum. On the proximal surface with the existing filling,



A. *B.*

Fig. 3.—*A*, A preparation for a three-quarter crown with a box in the proximal surface. *B*, An incisal view of a box preparation on one proximal surface and a groove on the other.

a class II box preparation is made in place of the usual groove (Fig. 3). If both proximal surfaces contain large fillings, a box preparation is made on both surfaces. If the lingual walls are smaller than is desired for adequate retention, one or more pinholes may be used. A hole is drilled in the lingual cingulum or in the dentin of the mesial and distal cervical floors toward the lingual surface with a No. 701 tapered fissure bur to a depth of 2 to 3 mm. The remainder of the preparation is finished in the usual manner, either with a chamfer at the cervical margin or a small shoulder with a cavosurface bevel.

With this type of preparation, it is not necessary to overcontour the proximal surface to accommodate stress breakers on fixed partial denture abutments or precision attachments on removable partial dentures.

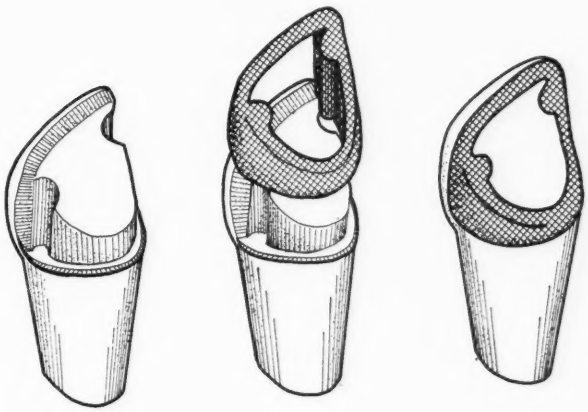


Fig. 4.—*A*, A modified three-quarter crown preparation with proximal grooves and incisal reduction. Note that no tooth structure is removed from the lingual surface except for the cervical shoulder. *B*, The cervical shoulder with a cavosurface bevel. *C*, The restoration is in place.

MODIFIED THREE-QUARTER CROWN PREPARATION WITH AN OPEN-FACED LINGUAL SURFACE

Occasionally, the conventional type of preparation for a fixed partial denture abutment is not indicated. This would be true when an upper incisor is involved, when the tooth is very thin labiolingually, when the gingivoincisal length of the upper and lower teeth is unusually short, or when the lower anterior teeth contact the lingual surfaces of the upper anterior teeth. The lingual surfaces of the upper anterior teeth or incisal edges of the lower anterior teeth should not be reduced in thickness under these circumstances.

The typical proximal slices are made with a diamond disk, making sure to converge the slices toward the cingulum. The incisal edge is tapered lingually with

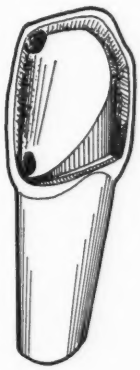


Fig. 5.—The lingual surface of a modified pinledge preparation showing the proximal, incisal, and lingual grooves and the positions of the pinholes.

a stone at about a 45 degree angle and reduced about 1 mm. in height. The grooves in the proximal surfaces are made with a regular cross-cut fissure bur instead of the usual tapered fissure bur (Fig. 4). A slight movement of the bur to the labial and to the lingual will produce adequate taper and still retain a larger groove at the cervical end than would have been obtained with a tapered fissure bur.

The gingival portion of the preparation consists of a shoulder 1 mm. in width and extends from the mesial groove to the distal groove. A bevel is made on the cavosurface angle of the shoulder.

The entire lingual surface remains untouched like a window or open-faced crown. No enamel is removed from the lingual surface of the tooth.

The use of a shoulder with a cavosurface bevel at the cervical margin instead of a chamfer increases the rigidity of the casting.

PINLEDGE OR PINLAY PREPARATION

In fixed partial prosthodontics involving the cuspid as the anterior abutment, a pinlay or pinledge preparation may be used. When the mesial surface of a cuspid as an abutment is not involved with a filling or caries, appearance should be a primary factor in the choice of retainer used.

The distal proximal slice is made with a diamond or carborundum disk. The slice converges toward the cingulum, with as little of the distolabial surface removed as is necessary.

The lingual surface is reduced with a diamond stone except in the mesiolingual area (Fig. 5). The amount of lingual and incisal reduction must be sufficient to accommodate an adequate thickness of gold so that it is not in contact with the opposing teeth in centric or lateral occlusions.

An incisal V-shaped groove is made with an inverted-cone bur or diamond stone. The distal proximal groove may be continued from the incisal groove either as a V-shaped or a curved groove. The lingual groove is a continuation of the incisal groove and is V shaped.

The cervical part of the preparation is either a chamfer or a 0.5 mm. shoulder with a cavosurface bevel.

A pinhole is drilled on the lingual surface at the junction of the incisal and lingual grooves. A second pinhole is drilled in the lingual cingulum and a third hole at the base of the proximal groove. These holes are 2 to 3 mm. deep and parallel to the proximal groove.

The advantage of this preparation over the conventional three-quarter crown is entirely in appearance.

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FULL ARCH SPLINT

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A FULL ARCH SPLINT INVOLVES the splinting of all remaining teeth in the arch and the replacement of any missing teeth in a one piece fixed restoration extending from molar to molar (Fig. 1). The advantages of a full arch splint are similar to those of other fixed partial dentures except that since so many more teeth are involved, much more care and thought must be used.

ADVANTAGES OF SPLINTING

1. A full arch splint immobilizes weakened teeth better than other restorations.
2. Full coverage on the abutments minimizes recurrent caries.
3. A smooth gingival finish of the castings allows the gingival tissues to remain healthy, especially where large gingival cavities and overhanging fillings existed before.
4. A splint retards or stops over-all or localized bone loss around the remaining teeth.
5. A splint eliminates the need for lingual or palatal bars so the palate and floor of the mouth have their natural forms.
6. A full arch mandibular splint is better than a straight partial arch splint,[1] since it directs the occlusal forces on the slopes of the posterior teeth in such a way as to produce a lingual resultant force. This resultant force may pass through or near the center of rotation, which is usually lingual to the tooth, thus causing little or no torque (Figs. 2 and 3). This is not the situation in maxillary curved arch splints, since these splints distribute more torque to their support. The occlusal line of force falls at a greater distance from the center of rotation of the splint than it does in mandibular splints. However, the amount of buccolingual movement of the upper teeth is reduced by a full (curved) arch maxillary splint, as compared to the movement with splints made in a straight line.
7. A full arch splint permits the patient to apply more occlusal force than can be applied on removable appliances.
8. Excellent esthetic results can be achieved with a full arch splint, and it gives the patient a feeling of confidence.
9. A full arch splint minimizes the buccolingual and mesiodistal movement of abutments.

INDICATIONS FOR OCCLUSAL RECONSTRUCTION

Occlusal reconstruction is indicated where there are gingival recession, bone loss around the teeth, loose teeth, and traumatic occlusion.[2]

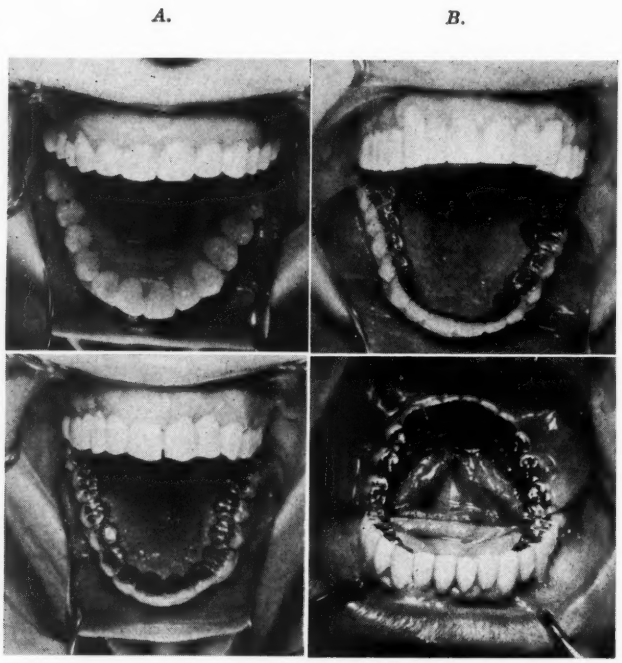

Fig. 1.—The full arch splint involves all remaining natural teeth in the dental arch.

A disturbance in muscular equilibrium causing unequal pressure on a specific segment of the dental arch could cause unequal wearing of certain teeth so that an abnormal occlusion may develop. Eventually, this unequal tooth wear causes occlusal trauma because of tooth interferences in lateral and protrusive movements of the jaw. Teeth remaining above the occlusal plane loosen and eventually are lost. The breakdown may continue, causing the final destruction of the dental mechanism.

Acute dental decay, especially as encountered in adolescence, may initiate the need for occlusal reconstruction. The patients, because of their youth, may not submit to extensive dental procedures. The result is an inability of the dentist to do good work. These patients often require complete reconstruction at around 40 years of age (Fig. 4).

The early loss of teeth because of decay or injury coupled with failure to replace them causes collapse of the dental arches (Fig. 5). The loss of teeth is usually accompanied by rotation, tipping, or migration of the remaining teeth. Interference with masticatory movements develops which causes further collapse of the dental mechanism. These patients sometimes require restoration of the vertical dimension of occlusion. A functional eccentric occlusion may result which is not in harmony with centric relation and may lead to unequal tooth wear.

Mechanical abrasion, attrition, or chemical erosion may reduce clinical crowns so that the pulps are endangered or facial appearance is affected (Fig. 6.) The re-

duction of the height of the cusps increases the force that must be developed by the musculature during mastication.

Food impaction is caused by shifting of contact points from shortened, rotated, and shifted teeth (Fig. 7). The resulting paradentosis may indicate the need for occlusal reconstruction.

A disturbance in the glenoid fossae may be caused by too much movement of the condyles. This movement may be caused when the lateral forces of mastication gain predominance over the vertical forces as the cusps are worn down.

Systemic causes may be a great factor in occlusal breakdown.[2-4] When the microscopic equilibrium in the remainder of the skeletal system is shifted in favor of resorption as a result of a systemic disturbance, a similar condition also prevails in the alveolar bone. The loss of alveolar bone occurs regardless of the condition of the gingival tissues or the structural details of prosthetic restorations.

Congenitally missing teeth or peg-shaped teeth necessitate rehabilitation to improve appearance and function (Fig. 8).

QUALIFICATIONS FOR TOOTH ABUTMENTS

The bone support can be fair or poor, and the teeth can be mobile.[5] The roots can be average or short, and the teeth can be pulpless. The mandibular molars may

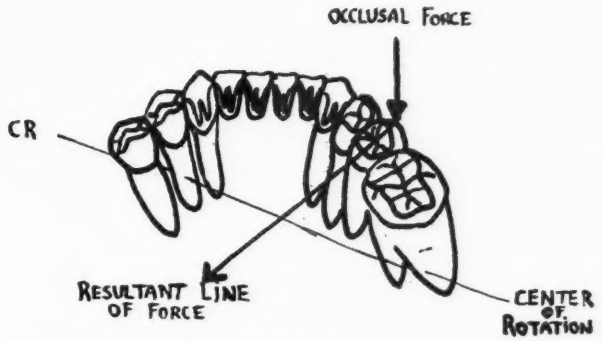

Fig. 2.—The occlusal forces on the buccal slope of a posterior tooth in a mandibular curved-arch splint produce a lingual resultant force.

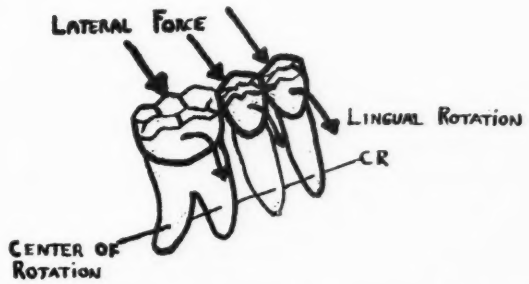

Fig. 3.—A vertical force on the buccal slopes of a mandibular straight arch splint results in forces perpendicular to those inclines. The lateral forces produce lingual rotation of the splint about the center of rotation *(CR)* which passes through the apical third of the teeth.

Fig. 4.

Fig. 5.

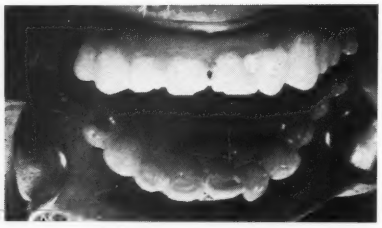

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 4.—Rampant caries often necessitates full arch reconstruction.
Fig. 5.—Collapsed dental arches may be caused by early loss of natural teeth.
Fig. 6.—These anterior teeth are worn because of mechanical abrasion and attrition.
Fig. 7.—Periodontal disorders are caused by improper contact areas.
Fig. 8.—Congenitally missing teeth may require reconstruction to improve appearance.

be severely tipped mesially. The surrounding gingival tissues and periodontal structures can be temporarily edematous or inflamed.

With the elimination of occlusal trauma and replacement of all missing teeth with the full arch splint, the remaining abutments are maintained in a state of immobility. This state of immobility keeps the teeth, bone, and soft tissues healthy when the splint fits passively and the occlusion is equilibrated.

RULES FOR FULL ARCH SPLINTS

Abutment preparations must be tapered buccolingually and mesiodistally and must be somewhat cylindric in shape, with no line angles. All of the abutment preparations must be parallel with one another.

The abutments that are either buccal or lingual to the dental arch should be reduced by grinding so that the pontics can be positioned as nearly over the crest of the ridge as possible. The completed full arch splint must fit over all abutments with complete passivity. It must not act as an orthodontic appliance.

No casting should be longer in a cervico-occlusal direction than the longest remaining tooth that makes contact with an opposing tooth.[6] If the vertical dimension of occlusion must be increased, it should be done with a removable restoration, thus allowing the posterior teeth to erupt to a new occlusal level.

The finishing lines should be prepared as far under the gingival tissues as possible. No apron of gold should be allowed to extend beyond the finishing lines of the castings.

Castings should not be bulky. Therefore, the dentist must remove enough tooth structure so that the castings can be the same size as the original tooth.

One or two teeth may be attached distally to the posterior abutment of a full arch splint in a cantilever fashion rather than a removable partial denture constructed to supply these teeth.

CONCLUSION

The full arch splint is used for maintaining immobility of the teeth, health to the periodontal structures, and comfort to the patient. Successful results need not be based necessarily on strong foundations. The full arch splint must fit passively for success.

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A NEW DIE MATERIAL FOR MASTER CASTS

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RUBBER-BASE IMPRESSION MATERIALS, carried in properly prepared trays, have proved to be capable of recording any surface or any preparation or margin that is adequately exposed. Die stones* are used extensively for the production of dies and working casts. They are easy to work with, accurate, and dimensionally stable, but they are too fragile.

A material used in industry for making molds, models, and dies has been found to be useful for making dies and casts for splints and other restorations. It is a plastic steel† which has the specifications, as furnished by the manufacturer, noted in Table I.

This plastic steel used in the construction of master casts has permitted completion of all castings, regardless of the complexity of the cast. Extensive splints containing up to eight abutments and fourteen units have been successfully constructed on this type of master cast. In several instances, a combination of fixed partial dentures with removable partial dentures has been constructed. Some of the partial dentures had precision attachments.

TECHNIQUE

The plastic steel is used as a die material in rubber-base impressions. All abutments which are to carry restorations are first poured in a dental die stone. Then the stone dies are removed from the impression after the die stone is completely set. The rubber-base impression is rubbed in its entirety with a pellet of cotton impregnated with a separating medium (a special release agent) in paste or liquid form to prevent the plastic steel from adhering to the rubber-base impression material. The impression is boxed with caulking rope.

The plastic steel is mixed in a disposable paper dish, e.g., a 3 ounce paper cup, in the proportions indicated on the label, and a few drops of thinner are added, if desired, to make the material flow more easily. After mixing, the material is carefully painted and flowed into the impression. When the desired level is reached, several spread paper clips are inserted at the edges of the plastic steel material to act as anchors for an artificial stone or plaster base which is used to complete the cast. The plastic steel material must be allowed to harden several hours. Its set may be accelerated by placing the poured-up impression in an incubator. When set, it is a little difficult to separate.

---

*E.g., Vel-Mix.
†Devcon WR.

Wax patterns are formed on the stone dies and taken to the master casts for occlusal, proximal, and contour adjustments. All gingival margins are finished on the stone dies; it is best to cut back the plastic steel from all margins with an inverted-cone bur (ditching the abutments) to permit the accurate seating of wax patterns.

TABLE I

SPECIFICATION	DATA
Ultimate compressive strength	16,000 p.s.i.
Tensile strength	8,000 p.s.i.
Flexure strength	11,000 p.s.i.
Relative impact strength	0.8 foot-pounds per inch of Notch IZOD
Rockwell hardness	F-93
Resistance to heat	300° F.
Dielectric constant	2.9
Machining qualities	Poor
Specific volume	15-16 cubic inches per pound
Shrinkage on 4 by 3 by 1 casting	0.00016 inch per inch

DISADVANTAGES OF THE MATERIAL

1. Its color is black. If stone dies are not used, the plastic steel can be used as individual dies which are also part of a master cast, i.e., in the Di-Lok tray technique, by adding red color concentrate or using ivory inlay wax for contrast.
2. The material is more difficult to mix than die stone.
3. It is necessary to use a separating medium before the master cast is poured.
4. A separating medium is necessary if the wax patterns are to be formed on the plastic steel.

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OPERATIVE DENTISTRY

PREVENTION OF DENTAL CARIES

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THE PREVENTION OF DISEASE generally depends upon understanding its cause, and in respect to caries, a consideration of causation is necessary if only to identify the areas in which progress has been made toward its control. Since prevention depends upon what developments take place prior to cavity formation, that is, on the outside of the tooth, the conditions which determine whether the enamel surface will remain intact or be broached by dental decay will be examined. These may be grouped as (1) factors related to the saliva, (2) factors related to the structure of the tooth surface, and (3) factors related to bacteria-saliva-food complexes which form on the tooth surface.

However, constructive consideration of these can be made only if one has as a starting point an acceptable theory of the nature of the caries attack.

The reasons for believing that the caries attack is the result of bacterial fermentation of carbohydrates on the tooth surface are overwhelming. They include at least 1,500 years of repeated observation that it occurs in relation to eating of sweet foods and their retention on the teeth. Modern work by Jay,[1] Becks,[2] Gustafsson,[3] and Weiss and Trithart[4] has amply confirmed this association. That factors operating on the outside of the tooth are more important determinants of the caries attack than those related to tooth development or tooth metabolism is established by the differential location of caries on specific tooth surfaces. How else can a six hundred fold difference[5] in caries incidence between tooth surfaces formed at the same time and exposed to the oral environment during the same period be explained? Further proof of the external action of carbohydrates in caries is supplied by demonstrations that sugar-containing diets which produce caries in animals[6] will not do so if they are fed by stomach tube.[7] That bacteria play a part is shown by the effect of penicillin on animal caries[8] and the failure to produce cavities when sterile caries-producing diets are fed to bacteria-free animals.[9] That acid is a part of the caries mechanism is indicated not only by theoretic considerations of the destructibility of the enamel[10] but also by its presence in caries-producing plaques[11]

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and carious cavities[12] and by the effectiveness of fluorine, which increases tooth resistance to acid,[13] in reducing caries activity.

FACTORS RELATED TO SALIVA

That saliva plays a role in caries prevention is an old belief which probably had its origin in clinical observations of high caries associated with xerostomia or of the unusual cases of unilateral caries in association with loss of salivary function on one side of the mouth. Thirty years ago, Pickerill's[14] claim that a large alkaline flow of saliva is responsible for low caries had wide acceptance, but in the absence of up-to-date evidence, enthusiasm for this concept waned. Recently, animal experimentation and other research reawakened interest in saliva as the possible mediator between caries and hormonal or metabolic activity.

It has been shown[6] in several laboratories that when salivary glands of animals are removed surgically, a dramatic increase of dental caries results. Thus, there is no question, at least in animals, that salivary flow is important in determining caries activity. Although this is generally believed to be the result of increased food stagnation, there is evidence to show that there is a more direct effect on the teeth.[15] This is that extirpation of salivary glands prior to placement of the animals on a cariogenic diet makes their teeth more susceptible to caries. Apparently, something in the saliva adds to the caries resistance of the teeth. This may be important because there is now ample evidence[16] to show that there is essentially no passage of minerals from the dental pulp to the tooth surface and that calcium and phosphorus that do get to the enamel posteruptively must be transported through the saliva. Thus, when there is a close balance between carious breakdown or resistance of the enamel surface, the action of saliva can determine the outcome.

Attempts to determine what variations in the composition of human saliva are associated with high or with low caries activity have not produced definite conclusions. This is partly the result of technical difficulties associated with its collection, storage, and analysis. Broadly speaking, laboratory findings show no firm correlation between caries and the physical properties,[17] alkalinity, or buffering capacity of saliva.[18,19] Some evidence indicates higher salivary flow in patients with little caries[20] and a greater tendency to transfer calcium or phosphate to enamel or tricalcium phosphate.[18] The last finding is of particular interest because it does suggest a mechanism by which the saliva could increase the calcification of enamel or remineralize it after it has undergone partial decalcification.

Whether effects of the sort mentioned above are large or small, they have special importance because they can represent a manifestation of the general metabolism of the body and the interrelated hormonal and nutritional factors operating at the enamel surface through the medium of the saliva. Unfortunately, knowledge of the extent to which hormonal and systemic factors modify the saliva is fragmentary. It is claimed that the amount of salivary flow may be influenced by thyroid activity,[6] that the adrenal cortex[21,22] has an effect upon the structure of the salivary glands and the nature of the salivary secretion, and that enlargement of salivary glands may occur in patients suffering from endocrine and nervous diseases and in association with the malnutrition and psychic stress of the ghetto

and concentration camp.[23] Some correlations have been claimed[24] between the diet and salivary composition. Although all these claims need confirmation, they have interest because they suggest ways by which the systemic conditions of the body can influence caries activity, and they provide a possible explanation for the increases in dental decay sometimes noted by dentists in debilitated patients.

FACTORS RELATED TO TOOTH SURFACE

G. V. Black's finding that caries-resistant teeth are no harder than those which are caries susceptible has stood the test of later investigations. A further reason why caries cannot be attributed to "softness of the teeth" appears in the finding[25] that brown spots and other acid-resistant areas on the teeth are actually softer than normal enamel. The reduced caries activity in old teeth seems to be associated with increases in the organic content[26] of the enamel surface rather than increased calcification. Other changes which occur in the tooth surface posteruptively include increases in amount of fluorine,[27] and this probably contributes to their increased resistance to decay with age. Like increases with age[28] in the lead content but not of some other metals suggest that any ion which will react with the enamel to form chemical complexes less soluble than the original surface will tend to accumulate there, producing a tooth surface of greater resistance to decalcification and dental decay. It is worth noting that organic chemical radicals, such as the oxalates,[29] reduce enamel solubility and that foods containing these can exert such an effect.

In addition to changes in the posteruptive enamel surface which may increase its resistance to destruction, there is growing confidence that such reactions could actually serve as remineralizing mechanisms and provide a sort of repair to enamel after it has undergone initial destruction.[30] Evidence that this does take place can be found by the demonstrated[31] increase in uptake of radioactive isotopes in caries and pre-carious white spots of the enamel surface. In short, the enamel surface must be thought of as undergoing physicochemical changes which operate toward its protection or repair as well as toward its destruction.

FACTORS RELATED TO BACTERIA-SALIVA-FOOD COMPLEXES

Reduction of Bacterial Activity.—Efforts to reduce caries activity by reducing the bacterial population on the teeth or interfering with the action of the enzymes by which the bacteria form acid have not been very successful. Although penicillin[8] will almost eliminate caries in animals, it is not practical to use it for caries control in man. Although there is no significant evidence to prove it, the removal of fixed bacterial deposits (plaques) by means of toothbrushing may have importance in disturbing bacterial symbioses which, for emerging theoretic reasons, may be specially destructive to the teeth. Much research[32] has been devoted to enzyme inhibition, but the value of recommended agents has not been established. The weakness of this attack on caries is that like all methods which depend upon regular and conscientious use of dentifrices or other products, it will be effective only in the hands of a small section of the population. This is also true of approaches which

depend upon rigid dietary controls. While there is little doubt that stringent reduction of carbohydrate intake will control caries, many nutritionists[33] advise against attempting to change food habits without making a substitution of some sort. Recent findings are indicating ways of doing this. One of these depends upon the frequency of eating, the other on differentiation between carbohydrate foodstuffs.

Reduction of Carbohydrate Factor.—Two clinical studies emphasize the importance of the frequency of eating. In one of these, Weiss and Trithart[4] found that preschool children who had no between meals snacks had the least caries, and there was a stepwise increase of caries with more frequent eating up to those who had four or more snacks and who had the most decayed teeth.

In the comprehensive Vipeholm Study[3] in Sweden, various patient groups were fed different types of carbohydrate diets, including varying quantities of between meal or mealtime sugar for periods of 1 or more years. The only groups which showed active caries were those who ate sugar between meals. These findings confirm observations[34] on the racial distribution of dental caries and are in accord with the experience of dental practitioners, findings in institutionalized children, and the results of several studies in which comparisons have been made between groups of patients with high and low caries activity.

Laboratory investigations have supplied adequate explanations of why the frequency of eating is important in caries by showing that the period of acid formation on the tooth surface after a single dose of sugar lasts only from 15 to 30 minutes[11] and that carbohydrates persist upon the tooth surface only a short length of time after eating.[35] Therefore, regardless of whether one takes a pound or an ounce of sugar in a given period of time, the length of the caries attack will be essentially the same. If, however, the pound of carbohydrates were divided into 16 ounces and taken separately, there would, theoretically, be about sixteen times the caries attack as if the pound of carbohydrate were eaten all at once. This conclusion that the frequency of eating carbohydrates is a dominant factor in caries causation cannot be emphasized too strongly. If a dentist can give only one piece of advice to patients, it should be: "The most important single thing you can do to reduce dental decay is to reduce the frequency of eating sweet food."

That foods differ in their cariogenicity is an ancient concept. However, it is only in recent years that efforts have been made to rate carbohydrate-containing foods according to their caries-producing effects. Over the past 10 years, a number of approaches have been made to this problem. These include measuring the amount of sugar recoverable in the saliva after eating of foodstuffs,[36] measuring the amount of the foodstuff actually adhering to the teeth after eating,[35] measuring the amount of acid formed on fermentation of the foodstuff in saliva[35,37] and combining this measurement with the amount of food on the tooth surface,[35,38] measuring the amount of acid formed in cavities,[12] measuring the amount of acid present in vivo in plaques and saliva,[39] measuring the amount of caries activity produced in animals,[40] and measuring the amount of decalcification of enamel produced by fermentation of foodstuffs and correlating this with the amount of acid formed.[41,42] These investigations have not produced clear-cut answers, and only a few of the findings can be used as a basis for dietary recommendations.

One conclusion of some value is that all of the evidence seems to show that liquid carbohydrates will be less conducive to caries than corresponding amounts of solid or dry carbohydrates. They leave less sugar in the saliva,[36] on the teeth,[35] and in cavities,[12] they form no more acid,[39] and they cause much less caries activity in animals.[43,44] Clinical evidence in human subjects was found in the Vipeholm Study, in which a group of patients who consumed 94 Kg. of sugar per year (mainly in tea and coffee) had only about one-third the amount of caries that resulted from one-half the quantity of sugar in a solid food. These findings, taken into consideration with the fact that there seems to be an almost inverse relationship between the carbonated beverage consumption in different parts of the country and the amount of dental caries[45] puts one on safe ground to say, "If sugar must be taken between meals, it is better taken in liquid than in any other form."

Refined and Unrefined Carbohydrates.—It has been found[37] that the unrefined carbohydrates produce much more acid than do the refined ones. However, measurements of the amount of enamel decalcified in saliva-foodstuff mixtures show[42] that in spite of their greater acid production, some unrefined wheat flours and sugars dissolve less enamel than do the refined ones. In short, there is either some difference in the types of acids formed on the fermentation of these unrefined carbohydrates, or there are one or more protective factors in them which, in spite of the higher concentrations of acid present, act in some way to protect the enamel surface against decalcification. This finding gives more scientific justification for the recommendation of unrefined as against refined carbohydrates than has so far been available. However, on the basis of today's information, any such recommendations are still premature, except possibly for wheat and sugar. They do not seem to apply to some natural sugars such as honey, which, on the basis of preliminary experiments, seems to be particularly destructive to the enamel. That milk solids, in addition to bran and wheat germ, reduce the decalcifying power of saliva fermentation mixtures would seem to offer an explanation of how milk solids reduce rat caries when fed after tooth formation is complete[46] even though they have no effect when fed only during the period of tooth formation.

While my thinking is that the protective action is associated with the inorganic salts of the natural grains of sugar which are removed by the refining processes, there are also reasons for believing that organic substances, such as phytic acid[47] or aspartates,[48] in the unrefined products may play a part. Whether the protective action is the result of buffering or common ion effect, a change in the types of acids formed, surface "remineralization," or adsorption phenomena is not known. Possibly, all play a part. Regardless of how such protective effects are produced, the fact that they exist in some natural foods suggests that if their nature could be determined, it would be possible to leave them in foods or return them in concentrated form to refined foods, thereby making these less cariogenic without interfering with their taste appeal. This would greatly simplify the dietary control of caries.

SUMMARY

The enamel surface is the site at which attempts at caries prevention can most profitably be concentrated. In this connection, it was pointed out that saliva not

only serves to keep the tooth surface clean but may, in some way, reinforce it and make it more resistant to dental decay. At this time, methods for increasing the protective effect of saliva are not known. It was pointed out that the tooth surface seems to undergo reactions with its oral environment, resulting in "chemical maturation," which makes it more resistant to the destructive forces of dental decay. The action of fluorine is an example of such an effect and makes its use, either in water supplies or as applications on the teeth, the most practical procedure for the partial control of caries. That fluorine has such an effect suggests that other agents, including natural food constituents, might also influence the destructibility of the enamel surface. It was concluded that attempts to control the bacteria on the tooth surface offer little promise of practical caries prevention. Instead, it was decided that the best hope of reducing the acid attack from bacteria-foodstuff complexes rests in reducing the frequency of eating sweet foods and that, at present, this is the only effective dietary recommendation which can be made. The advantage of substituting liquid or other carbohydrate foods of low cariogenicity for those with high cariogenicity was suggested as a promising approach to the dietary control of caries.

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PERIODONTAL AND DENTAL HEALTH

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A TOTAL REVERSAL of former concepts of dental practice has developed into a more sane concept of what constitutes total dental health. We have learned that periodontal health is the *foundation* of good dental service and total oral health. A healthy dentition is predicated on a healthy periodontium.[1]

The history of any profession teaches that practice goes through stages. After the pendulum swings wide in one direction, it swings back to the same degree in the opposite direction. Thus, there is a tendency toward extremism. Dentistry went through such a cycle with pulpless teeth when they were treated with a total disregard of the condition of the teeth. Then followed a wave of tooth extraction, when all pulpless teeth were condemned and extracted. We have now arrived at a sensible, middle of the road stage.

At present, we are going through a cycle of heroic treatment of teeth affected by periodontal disease. We have made great strides in the diagnosis and treatment of such diseases. However, there is a tendency to resort to heroic and ill-advised efforts to save teeth with advanced periodontal disease which should be extracted. Others are overemphasizing full crown coverage in restorative dentistry and oral rehabilitation.

WHEN SHOULD A PERIODONTALLY DISEASED TOOTH BE TREATED?

A common question is "When should we treat a periodontally diseased tooth, and when should the tooth be extracted?" The answer is that if such a tooth will respond to treatment and can be retained in a healthy condition, it should be treated and retained. If there is a reasonable doubt, it is good practice to treat it, to correct occlusal disharmonies and traumatic forces, to treat the soft tissues, to splint the tooth if it has mobility, and to try to restore it to a healthy condition. Treatment of teeth affected by chronic destructive disease for prolonged periods of time should not be encouraged or advised. If a periodontally diseased tooth cannot be restored to health in about 60 days, it should be extracted. Heroic treatment of hopeless teeth should be discouraged. A healthy pontic is a better neighbor than a periodontally diseased tooth.

HEROIC TREATMENT

Since the advent of full coverage crowns and the splinting of teeth weakened by periodontal disease, we have witnessed many untoward results of such treatment.

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In some instances, a tooth weakened by chronic destructive periodontal disease has been unwisely incorporated in a fixed partial denture and splinted to other, healthier teeth. When the periodontally diseased tooth inevitably developed an acute pathologic periodontal condition which required its extraction, a serious and difficult problem arose for both dentist and patient. To extract the tooth would necessitate removing all of the crowns included in the fixed partial denture and remaking the prosthesis. Such procedure would be embarrassing to the dentist and painful and expensive for the patient. To obviate such a procedure, a technique was developed which consists of making a gingival flap over the root or roots of the infected tooth, removing the buccal plate of bone overlying the root, separating the root from the crown of the tooth, and extracting the root. The gum flap is then sutured into place, the coronal portion of the diseased tooth is left within the cast crown, and the prosthesis is retained intact. This is a trend which needs re-evaluation.

Such an example is shown in Fig. 1 where a lower central incisor, impaired by chronic destructive periodontal disease, was incorporated in a fixed partial denture. There are three-quarter veneer crowns on the right cuspid and left central and lateral incisors, replacing the right central and lateral incisors. Shortly after the prosthesis was inserted, the left central incisor developed an acute periodontal abscess, necessitating its extraction. To obviate the removal of the entire prosthesis, the root was resected and removed 1 month later with the results shown in Fig. 2, *A*.

When the tooth involved in such a situation is an upper bicuspid or molar, a larger crown remains containing the coronal remnants of the diseased tooth. The result is more extensive bone and soft tissue resorption and an unhygienic edentulous area for the collection of food and debris which is not self-cleansing.

This leads to some pertinent questions. Why are such periodontally diseased teeth incorporated in fixed partial dentures? How soon after such restorations are inserted is it necessary to remove the diseased teeth involved? Why are not such teeth extracted *before* the fixed partial denture is constructed? Would not a healthy pontic be a better neighbor than a hopelessly diseased tooth? Is a crown containing

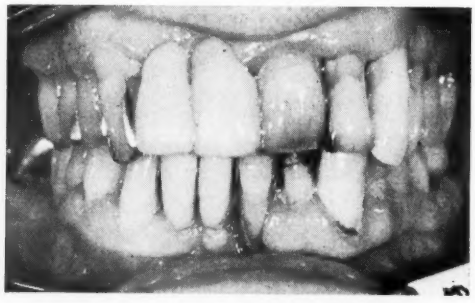


Fig. 1.—Heroic treatment. The lower left central incisor, an abutment tooth in a fixed partial denture, has a hopeless prognosis. Note the severe bone loss around the root and the deep periodontal pocket formation, evidence of chronic destructive periodontal disease. (Courtesy of I. Glickman.)

the coronal remnants of a diseased tooth a proper and healthy type of pontic to be left in a mouth? Will it not act as a reservoir for putrefying bacteria, food, and debris and a source of infection? And what happens when the alveolar bone and gingivae beneath the crown are resorbed and a permanent space results beneath this unhealthy locus, as evidenced by the roentgenograms in Fig. 2, *B*?

PARTIAL COVERAGE

Before we discuss the harmful results from improper full coverage, an example of partial coverage for a fixed splint, whether of pinledge or three-quarter veneer crowns, is presented for evaluation. In Fig. 3, *A*, is seen an example of splinting five upper anterior teeth showing evidence of progressive alveolar bone loss and spaces between the teeth in a woman age 55 (Fig. 3, *B*). The teeth were splinted with three-quarter veneer crowns as shown in Fig 4. Note the accuracy of the cervical fit of the castings, the normal sluiceways, the proper interproximal contact points, and the healthy condition of the gingivae, labially and palatally, over 2 years later. The castings do not extend below the gingivae and do not impinge on the marginal gingivae. The pulps were not endangered, and the labial esthetic appearance of the natural teeth is retained. Compare this example with the full coverage restorations in Figs. 9 and 10.

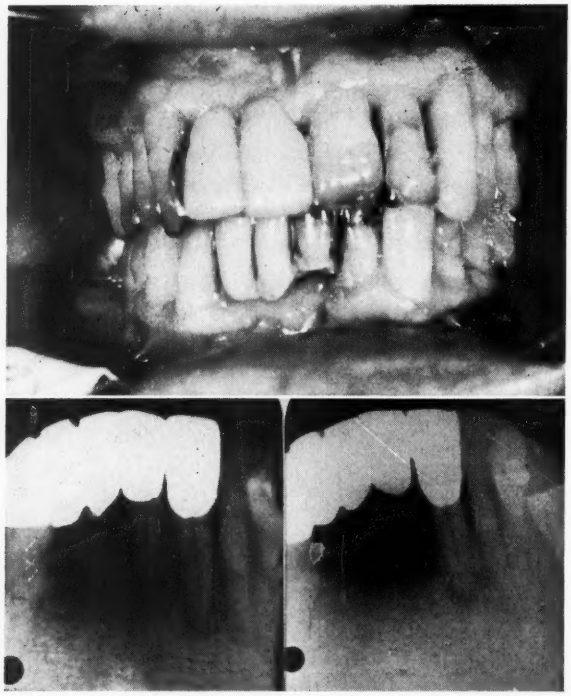
TREATMENT PLANNING

Any dentist who feels qualified to practice restorative dentistry should be competent to make a diagnosis and arrive at a treatment plan decision *before* he incorporates periodontally diseased teeth in a fixed partial denture. If a tooth has a hopeless prognosis, it should be extracted. A healthy pontic would be a better neighbor for the remaining teeth in a restoration than the hopelessly diseased tooth that should succumb to the forceps.

FULL COVERAGE

As a result of experiences with full crown coverages, the pendulum is beginning to swing in the opposite direction.[2-5] Roentgenograms can reveal mesial or distal overhanging margins on full crowns (Fig. 5, *D, E,* and *F*) or instances where a crown is short at those margins (Fig. 9, *E* and *F*), but even a roentgenogram will not disclose overhanging margins on the buccal or lingual surfaces or inadequate coverage at those areas. Periodontists have noted gingival inflammation, hypertrophy, bluish discoloration of the marginal gingivae, congested hemorrhagic gingivae, spontaneous bleeding, and gingival recession about teeth which have been covered with full crowns. Pulp exposures are often encountered in the preparation of teeth for full coverage.[6,7] In many instances, the fabricated crowns are oversized and unfaithful in anatomic reproduction. Such crowns have broad interproximal contact surfaces instead of properly restored contact points. Normal sluiceways are absent. Interdental spaces are obliterated, and the normal interdental gingival papillae are replaced by puffed, engorged, abnormal tissue. Marginal ridges have been obliterated or often placed in unequal occlusal relations.

A.



B.

Fig. 2.—*A*, Although the root of the left central incisor has been removed, the crown has been left in place. Note the unesthetic appearance and the unhygienic space between the tooth and the gingivae. *B*, Roentgenograms showing resorbed alveolar bone resulting from the extraction of the left central incisor root. (Courtesy of I. Glickman.)

Full crown coverage introduces the risk of damage to the periodontal tissues, the gingivae, the highly sensitive fibers of the periodontal membrane, and other gingival and subgingival soft tissues. These are matters of great concern to many dentists as well as to periodontists. Some or all of these factors are responsible for much of the periodontal disease observed. The full crown trend has been condemned as harmful to periodontal tissues and incompatible with conservation of healthy tooth tissues by Weinberg[4] and others [5,6] who have related the many problems associated with full coverage.

ACRYLIC RESIN VENEER CROWNS

The full acrylic resin veneer crown is an excellent and valuable means of restoring a badly broken-down tooth or for a bridge abutment, if it is properly constructed.[1] However, many periodontists believe a full crown should be utilized as a measure of last resort, if no other suitable type of restoration can be made. The trend to substitute pinledge and three-quarter veneer crowns for the full coverage crowns has begun.[2-5]

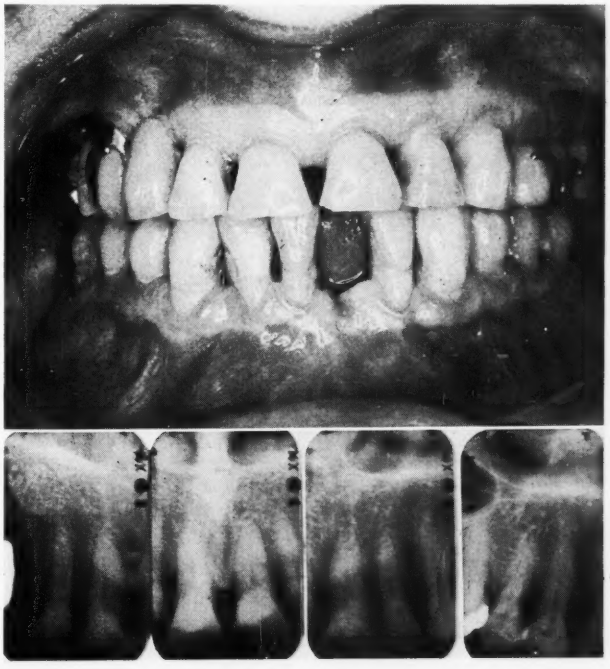
In addition to numerous other advantages, the labial surfaces of the teeth involved are not destroyed, and numerous pulp exposures[6,7] are thereby avoided. One is never certain how far labially the pulp extends in any tooth. In preparing teeth for full coverage, many pulps have been inadvertently exposed. The pinledge and three-quarter veneer crown is tapered to a definite finishing line at the cervical margins of the tooth, and the casting is carried to that finishing line. The castings do not impinge on the cervical gingivae, and they preserve the integrity of the soft tissues. The health and appearance of the abutment teeth and the gingival tissues will be better. Acrylic resin facings change color and, because of their softness, are frequently worn down to the gold veneer by brushing and abrasion. The buccal contour is destroyed and the gingival tissue protection endangered.[6]

CASE REPORTS

Many examples could be presented to illustrate the harmful results from improper full coverage, but two are presented here for study and evaluation.

Case 1.—A woman, age 35, required treatment of the lower teeth. The upper teeth had been restored. The lower right second bicuspid and molars were missing and replaced by an ill-fitting unilateral, distal extension removable partial denture. The left bicuspids and molars had deep and extensive amalgam fillings (Fig. 5, *A*). After the removal of the fillings, the pulps were

A.



B.

Fig. 3.—*A*, Preoperative view of the upper anterior teeth, showing spaces between the teeth and the healthy appearance of the gingivae. *B*, The roentgenograms show evidence of progressive alveolar bone loss.

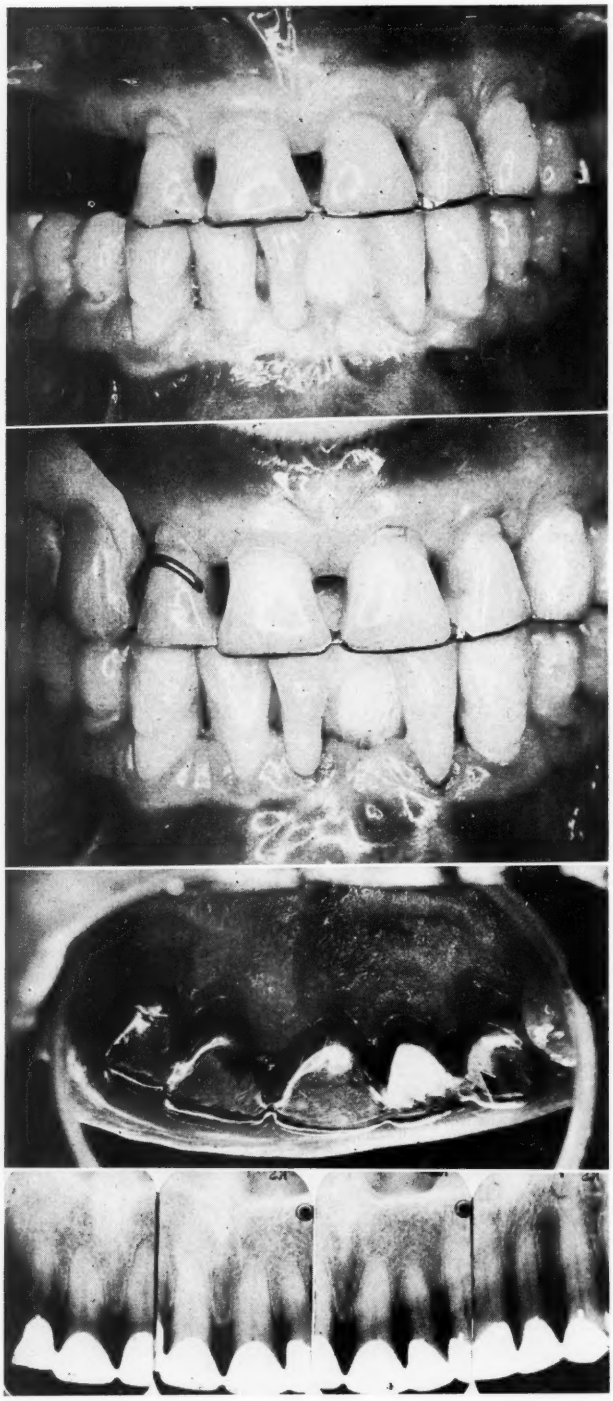


Fig. 4.—*A*, After splinting of teeth with three-quarter veneer crowns. *B*, The removable upper partial denture is in place. *C*, A palatal view of the castings. *D*, Roentgenograms of the splint.

found to be nearly exposed in the second bicuspid and the molars (Fig. 5, *B* and *C*). There was a bifurcation involvement of the first molar. I discouraged full coverage crowns. Instead, I advised extraction of these teeth and construction of a DO gold inlay for the first bicuspid, with an occlusal groove for a lug rest, and a bilateral removable partial denture to replace the second bicuspids and molars. The six anterior teeth were in good condition. The patient was anxious to minimize expense.

Two months later, the patient returned for a periodontal checkup of the restorations seen in Fig. 5, *D, E,* and *F*. The defects commonly seen in full coverage can be seen on all three crowns, which were splinted together: (1) the crowns have overhanging mesial and distal margins, (2) there are poor interproximal contacts and sluiceways, (3) the crowns have poor anatomic carvings, (4) the crown on the first molar is short at the distal cervical margin, (5) the bifiurcation of the roots of the first molar was aggravated by an ill-fitting crown impinging on the gingivae, and (6) puffed, edematous, hemorrhagic gingivae resulting from chronic irritation of improper full crowns are observed clinically.

Case 2.—A woman, age 45, was referred for periodontal treatment. Her mouth had received excellent care all her life. Evidence of periodontal disturbance was manifested by the enlarging spaces between the upper central incisors (Fig. 6). There were palatal periodontal pockets about 4 to 5 mm. in depth about the upper central incisors with very slight mobility. Fig. 7 shows the preoperative condition and the low frenum attachment. The marginal gingivae were healthy, and there was no marginal irritation or inflammation. A gingivectomy was performed on the upper four anterior teeth, and a frenectomy was done to ensure good postoperative gingival health. The periodontal treatments were completed, the traumatic occlusion was corrected, the deflective occlusal contacts were eliminated, and the diastema between the two central incisors was closed (Fig. 8).

The patient was referred to her dentist with a recommendation that the anterior teeth be splinted with pinledge castings. I strongly urged her dentist to avoid full coverage. The esthetic appearance of the labial surfaces of the anterior teeth would thus be preserved, and the integrity of the marginal and periodontal gingivae would be maintained. The risk of labial pulp exposures would be reduced. But the six anterior teeth were treated by full coverage. The roentgenograms in Fig. 9 were made about 3 months after the teeth had been covered and splinted with acrylic resin veneer crowns.

When I examined the patient, the most pronounced symptom was an enlarged, papillomatous, hemorrhagic papilla between the right lateral incisor and cuspid which bled spontaneously (Fig. 10). The marginal papillae around the six crowns were thickened and enlarged, slightly edematous, spongy, and slightly purplish in color. The shoulder joints were evident, and the left cuspid displayed a narrow gold cervical margin. The roentgenograms in Fig. 9 did not disclose any discernible overhanging margins *mesially* or *distally*. It has been pointed out that roentgenograms may not disclose labial or lingual overhanging margins or discrepancies. Careful examination with a periodontal probe disclosed a discrete overhanging margin on the distopalatal margin of the right lateral incisor crown. The roentgenograms (Fig. 9, *E* and *F*) disclosed a short margin at the mesiocervical margin of the right central incisor crown which will result inevitably in secondary caries. The occlusal relations of the splint were good. The appearance was unfavorable compared with the natural teeth.

SUMMARY

It seems obvious that dentists must approach the problem of full coverage with extreme caution, reserving that type of restoration for situations in which nothing else will serve the purpose. A return to the use of pinledge and three-quarter veneer crowns seems to be indicated to preserve the integrity of the periodontal tissues, to reduce the risk to pulps, and to increase averages of success in restorative dental procedures and mouth rehabilitation.

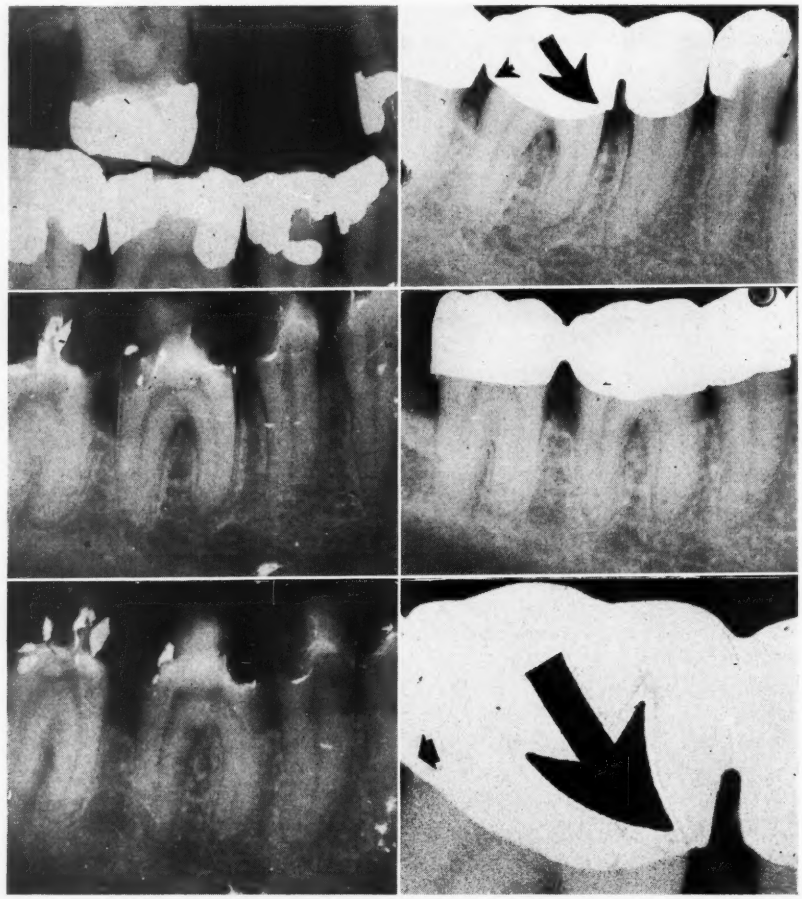
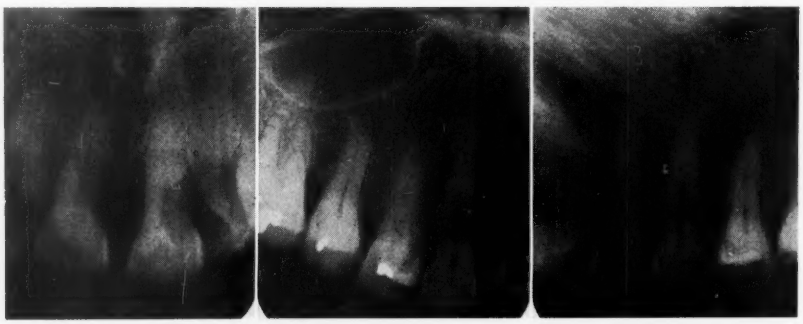


Fig. 5.—*A*, Deep and extensive defective amalgam fillings in lower left bicuspids and molars. *B* and *C*, The fillings have been removed, uncovering nearly exposed pulps in the second bicuspid and molars. *D* and *E*, Note the overhanging inlay in the first bicuspid and overhanging margins of crowns on the mesial and distal surfaces of the second bicuspid and second molar and on the mesial surface of the first molar. *F*, The large arrow points to an overhanging mesial margin of the crown. The small arrow indicates a short margin at the distal cervical margin.



A. *B.* *C.*

Fig. 6.—*A*, *B*, and *C*, Roentgenograms of upper anterior teeth. A diastema exists between the upper central incisors *(A)*. Note the loss of palatal bone with 4 to 5 mm. pockets.

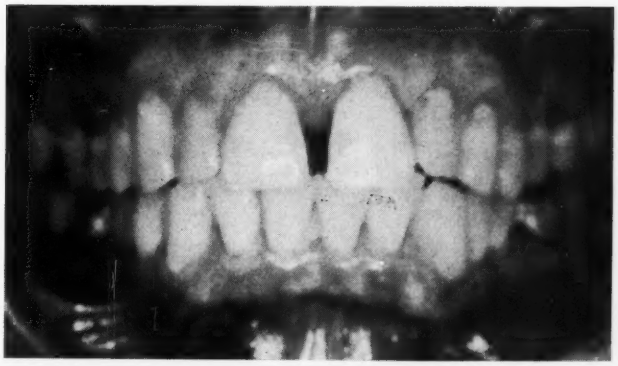
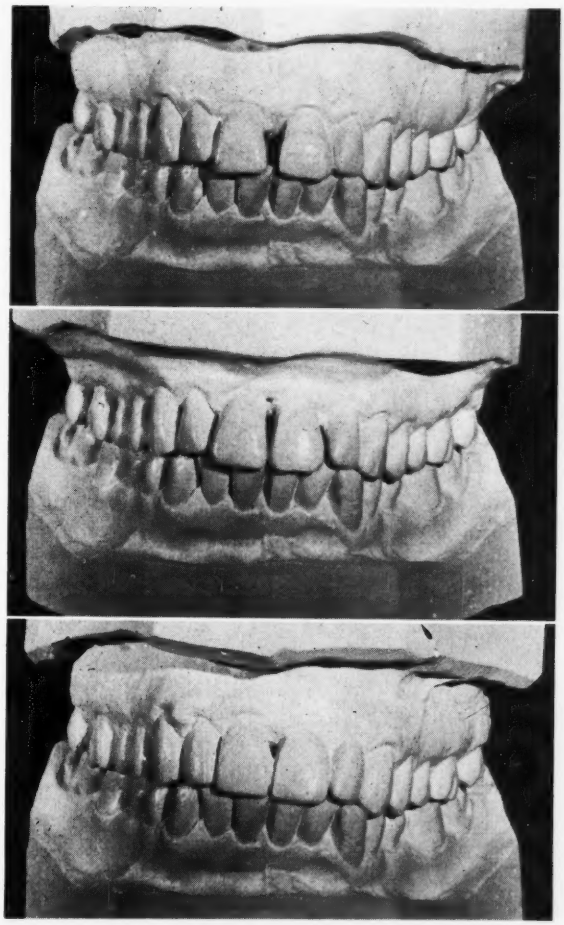


Fig. 7.—A preoperative photograph shows the diastema between the central incisors and the low frenum attachment. Note the normal, healthy appearance of the marginal gingivae and the absence of marginal irritation or inflammation.



A.

B.

C.

Fig. 8.—Casts of the mouth seen in Fig. 7. *A*, The preoperative casts. *B*, Casts made after periodontal treatment and frenectomy. The diastema between the central incisors has been closed. *C*, Casts made after full coverage and splinting of six anterior teeth. Note the thickened, irregular marginal gingivae and enlarged papillomatous papilla between the right lateral incisor and cuspid. Compare this with Figs. 7 and 10.

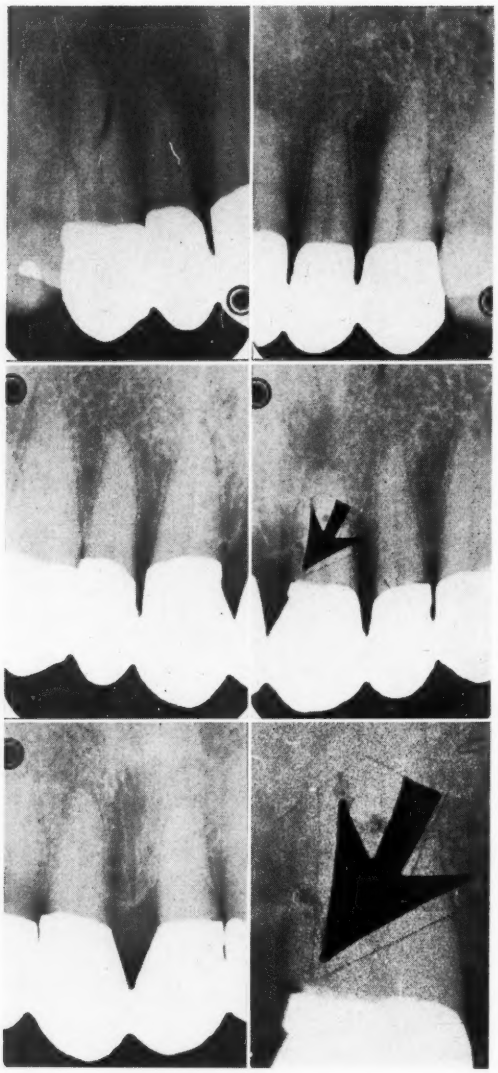
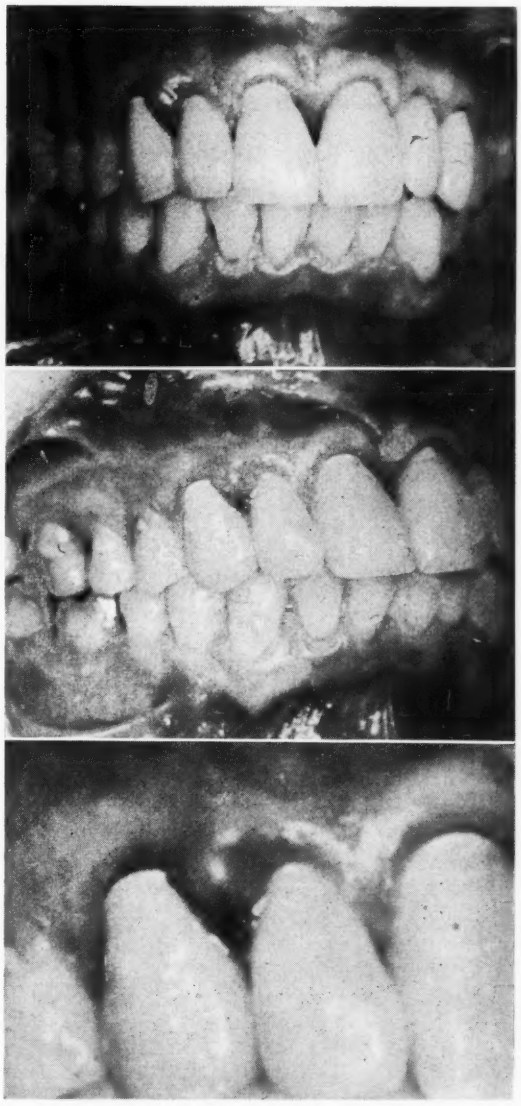


Fig. 9.—*A*, *B*, *C*, and *D*, Roentgenograms of crowned and splinted teeth. *E*, Note the inadequate coverage of the mesial margin of the right central incisor crown. *F*, The enlargement shows the area of the tooth that is vulnerable to secondary caries and inevitable failure of the entire splint because of the short margin of the crown.

Proper operative and prosthetic dental service is such an integral and inseparable part of periodontal health that dentists cannot provide one without the other. An effort has been made to present a concept of periodontal health and its relation to total oral health. There cannot be a healthy mouth with a diseased periodontium. It is basic that the periodontal tissues must be treated first to prepare a healthy foundation for the operative and prosthetic treatment to follow.

Heroic attempts to retain teeth which are periodontally diseased to a stage



A.

B.

C.

Fig. 10.—Response of the gingivae. *A*, *B*, and *C*, Note the thickened, enlarged marginal gingivae about all six crowned teeth with large, papillomatous, hemorrhagic gingivae between the right lateral incisor and cuspid. Note the exposed marginal contacts between the crowns and the prepared teeth and the unesthetic gold margin at the cervical margin of the left cuspid.

where they should be extracted must be avoided. Such teeth should not be incorporated in splinted fixed partial dentures. Splinting a hopelessly loose tooth will not tighten it; it will jeopardize the healthy teeth to which it has been splinted.

The indiscriminate use of full crown coverage should be discouraged. Experience with full coverage has taught that a return to the use of pinledge and three-quarter veneer crowns is indicated.

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ADULT DENTISTRY FOR CHILDREN

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DENTISTRY FOR CHILDREN embraces an age segment of the population from infancy to maturity. The dental problems necessarily include those of the primary, mixed, and permanent dentitions. Although these problems vary somewhat in the different age groups, they are basically similar and yield to similar methods of solution.

The excellent operative techniques utilized for adults can be easily adapted to dentistry for children. The dentition of a teenager is virtually that of an adult, and the adoption of operative techniques suitable for all ages simplifies the office routine.

CHILD MANAGEMENT

Child management is one of the first considerations in restorative dentistry for young people. This consideration is also the most difficult to teach or explain.

An understanding of the emotional problems of the child leads to a more sympathetic attitude on the part of the dentist. The dentist must understand his procedures and the judgment behind them so well that he has no fear of his ability to treat the child. The dentist must be kind and sympathetic, yet firm when necessary without becoming harsh. The dentist must give full attention to the child so that he can feel intuitively what the child is thinking and feeling.

SILVER AMALGAM RESTORATIONS

Silver amalgam has saved more teeth in the modern history of dentistry than any other material. The many tests on silver amalgam and its environment have aided in the development of an acceptable standard operating procedure for its use. Phillips[1] stated that about 56 per cent of amalgam failures can be attributed to improper cavity preparation and 40 per cent are caused by improper manipulation of the alloy. He also stressed that moisture contamination is a common cause of failure.

The foundation of an amalgam restoration for a child, as for an adult, is a proper cavity preparation. The cavity preparation in a primary tooth should be similar to that in a permanent tooth with slight modifications to protect the large pulp. A conservative preparation which preserves as much tooth structure as possible is satisfactory for the primary as well as the permanent teeth. Many class II preparations can be small enough that the strength of the remaining tooth structure will more than offset the loss of strength in the lesser bulk of amalgam.

Read before the American Academy of Restorative Dentistry in Chicago, Ill.

The ideal preparation can be cut with small burs. A No. 699L performs admirably with the air turbine. The only limitation to a narrow isthmus is the establishment of a smooth, flowing outline form as the preparation approaches the buccal and lingual proximal margins. The pulpal wall should be below the dentoenamel junction. The axial walls diverge as they approach the pulpal wall, making an inverted cone–shaped preparation that parallels the enamel rods. The buccal and lingual walls of the proximal part should be placed in self-cleansing areas at the occlusal surface but should remain as close together as possible to leave the maximum amount of tooth structure for necessary strength. The proximal walls diverge gingivally following the plane of the buccal and lingual surfaces of the tooth. Thus, the margins are kept in self-cleansing areas and the gingival extension maintains the proper outline form of the cavity.

All angles are rounded and the pulpal wall is deepened with a round bur to make a cone-shaped trough with the base at the axiopulpal angle. This form reduces the stresses in the filling and also provides additional bulk of amalgam for increased strength.

The only modification necessary for a primary tooth is that the deeper parts of the preparation (the cone on the pulpal wall) be kept narrow enough that it falls between the buccal and lingual horns of the pulp. All margins must be at right angles to the surface of the tooth to avoid either a thin edge of amalgam or short and loose enamel rods that cause marginal failure later. Retentive grooves are placed in the proximal surfaces with a No. 699L bur. The grooves taper out at the dentoenamel junction.

The gross preparation is developed under water spray but is always finished under the rubber dam to keep the area free from contamination. The value of the rubber dam in children's dentistry is even greater than in adult dentistry. Children salivate copiously, move about in the chair, and enjoy stalling the work by frequent trips to the cuspidor. The rubber dam overcomes all of these distractions.

The necessary instruments are placed on the cabinet when a rubber dam is to be used. These include a Young frame with dam attached, a rubber dam punch, clamp forceps, the desired clamp, and a short piece of dental floss. The Young frame is particularly valuable for children because it holds the dam in position without straps around the head. The frame is easy to place and also eliminates the feeling of claustrophobia sometimes experienced with the conventional rubber dam holder.

The clamps most commonly used are the S. S. White Nos. 30 and 31 and the Ivory Nos. 2 and 14. The No. 30 clamp is used on the right side of the mouth, the No. 31 on the left. The clamp is placed on the second deciduous molar, if present. The clamp is placed properly on the upper molar but is placed backward on the lower molar to give good retention with the minimum of discomfort to the patient. The No. 2 clamp is used on the second deciduous molar when Nos. 30 and 31 clamps will not hold, and it is used most often on the first deciduous molar. The No. 14 clamp is used on the partially erupted first permanent molars. Many other clamps may be used in unusual situations.

The first step in placing the rubber dam is the punching of the required roles. Only the teeth involved are exposed. The first hole is made with the largest size

punch. If additional holes are required, a punch two sizes smaller is used. A septum of about 2 mm. is left between the holes. Then, the clamp is placed on the tooth.

If the clamp is placed on the second deciduous molar, the pointed beak of the No. 30 or 31 clamp is placed lingually on the lower or buccally on the upper tooth. Then, the dam is stretched over the clamp, with the index fingers of both hands as guides. Dental floss is carried through the contact points, if necessary, and the dam is in position.

If the dam has poor retention on the mesial surface of the first deciduous molar or on an anterior tooth, a wedge made of a round toothpick is placed at the mesial surface of the most anterior tooth that is exposed. The rubber dam can be placed in little more time than is required to put cotton rolls in the mouth; it gives the dentist security against contamination as well as being much more comfortable to the patient.

An anatomic matrix is used because it provides an accurate reproduction of the tooth contour and is easy to use. The matrix material must be thin (0.015 inch) in order not to interfere in the establishment of contact. The matrix must be contoured to duplicate the proximal form of the tooth and must be supported to prevent springing during the condensation of the amalgam.

The strip matrix is satisfactory for most teeth. This matrix is composed of a short strip of material that is placed interproximally with the free ends extending approximately 2 mm. beyond the margins of the preparation. The strip is contoured before it is placed around the tooth. The wedge is forced into place to seal the gingival margin and provide a slight separation. Then, the matrix is supported by pressing a small pellet of softened modeling compound into the buccal and lingual embrasures. After the modeling compound has hardened, a warm instrument is used to perfect the proximal contour. The matrix is essentially a modeling compound matrix with a metal lining.

A band matrix can be made if the tooth is badly broken down and the preparation is extensive. The band material is pinched, welded into a band, and contoured. The use of thin matrix material permits the wedging, supporting, and final contouring of the band in the same manner as for the strip matrix. The anatomic matrix is used on primary teeth in a similar manner as on the permanent teeth.

GOLD INLAY RESTORATIONS

The technique for gold inlay restorations for children is the same as that used for an adult. The few inlays that I have made for primary teeth have all been made directly. Most of the inlays made for the permanent teeth of teen-agers have also been made directly.

CROWNS AND SPACE MAINTAINERS

Some discrimination must be used in the choice of a crown for full coverage. Most primary teeth, and in unusual circumstances some permanent teeth, can be restored satisfactorily with preformed steel crowns. However, when closer gingival adaptation, greater strength, and the longer wearing qualities of a cast gold crown are needed, a simple technique that minimizes cost to the patient is desirable.

I use a modeling compound impression for crowns and space maintainers for primary teeth. The tooth is prepared, and a preliminary impression is made with red modeling compound in a Willett tray. The impression is lined with green stick modeling compound and replaced on the teeth. The impression gives great detail and must extend below the gingival margin and into every minute depression. The impression is removed, and an investment cast is poured.

A wax interocclusal record is made of the prepared tooth only, using a double thickness of baseplate wax ½ inch long. The wax is warmed and placed over the preparation, and the patient is instructed to close the mouth. The wax record is preserved and used as the occlusal part of the wax-up of the crown.

The investment cast is broken so that the preparation can be waxed up individually, and then the section is placed back in the cast to check the contact areas. The wax record is placed on the occlusal surface of the cast and carved to the correct contour. The occlusal surface of the wax crown is carved from the interocclusal record itself. The waxing of the crown is completed in inlay wax, and the pattern and cast are invested. If the wax interocclusal record was accurate, the casting will need little correction before cementation in the mouth.

This same technique is used to make space maintainers. A platform of baseplate wax is extended across the edentulous space to contact the other abutment tooth. The junction of the crown and the platform is thickened slightly. Essentially, the platform is a cantilever fixed partial denture which retains the occlusal level and maintains the space. If the crown preparation is somewhat small to provide stability against occlusal displacement, a groove is placed in the buccal surface to improve retention.

REMOVABLE PARTIAL DENTURES

Removable partial dentures for children are, unfortunately, more common than one would expect. A small removable partial denture constructed of acrylic resin with wire clasps, much the same as the common temporary partial denture so often used on older patients, provides good service for most children.

However, the normal growth and development of the jaws of young children present a problem. This problem is particularly acute in the lower jaw because the cuspids are usually clasped for retention. The intercuspid width increases from 4 to 6 mm. during the period from 3 to 10 years of age, and a means for the denture to grow with the mouth must be provided. This change in the size of the denture is accomplished by the use of a lingual bar with a slip joint incorporated in its construction.

This extensile lingual bar can be made easily with a double tube and wire. Two pieces of 0.032 inch tubing are soldered together and then soldered parallel with, and overlapping about 2 mm. of the end of, a piece of 14 gauge half round wire. This forms half of the lingual bar. A piece of 0.032 inch wire, bent double, is passed through the tubes, and the ends are soldered to another piece of 14 gauge half round wire with about 2 mm. of solder joint allowed. This completes the lingual bar. The extension is provided by leaving a loop of wire 2 to 3 mm. long on the side of the double tube opposite the solder joint between the wires and the 14 gauge

half round wire. The double tubing provides the necessary lateral stability for the joint. An extension 2 mm. long provides for about half of the expansion to be expected. When the joint is fully open, a new removable partial denture is constructed with the same lingual bar in most instances.

Removable partial dentures serve as space maintainers, retain the occlusal level of the opposing teeth, and also provide the child with something with which he can chew. Children adapt to the dentures quickly when the occlusion and the borders are carefully adjusted. Usually, no adjustments are necessary.

GOLD FOIL RESTORATIONS

The use of gold foil for children provides the dentist with service that is unequaled in other operative procedures. All of the arguments for the use of gold foil in adults are just as valid for its use in young people; moreover, there are some additional advantages and a minimizing of some disadvantages.

Gold foil can be used readily in the primary teeth to fill the small labial pits frequently found in the newly erupted cuspids. A 3-year-old child easily will sit for a small gold foil restoration, even for small class V cavities on the primary cuspids.

The primary cuspid should be retained until the child is about 12 years of age. This gives a life expectancy of about 9 years to a restoration for a 3-year-old child. The relatively lengthy time element justifies the small additional effort required to place gold foil instead of another material. The gold foil provides security against corrosion and discoloration.

The young permanent teeth offer a greater opportunity for the use of gold foil than teeth of older patients. Lingual pits on the upper lateral incisors and buccal pits in the lower first permanent molars are almost universal in children 6 and 7 years old. Slight hypoplasia results many times in pits in the buccal and lingual enamel of any permanent tooth. The margins of all of these preparations can be placed in self-cleansing areas with a minimum of extension. The long life expectancy and the inherent qualities of gold foil make it the logical material for such cavities.

The loss of the second primary molar exposes the mesial surface of the first permanent molar, with the frequent disclosure of incipient caries. These mesial cavities on first permanent molars lend themselves conveniently to restoration by gold foil. However, the margins must be extended to assure their placement in self-cleansing areas. The actual carious lesion is used for the retention of the filling; the marginal outline is developed with a long bevel from the retentive part to the margin. This type of preparation conserves tooth structure and avoids undermining and weakening the marginal ridge.

Classes I, II, and V cavities are treated similarly as in an adult. However, two considerations are strictly observed on young patients. The preparations are as conservative as possible, and the teeth are always supported during condensation of the foil. Many times, one finger can provide all the support necessary, but the tooth is usually supported with modeling compound.

The class III gold foil restoration on young permanent anterior teeth may be

used successfully. The original complaint that the young tooth cannot stand the trauma of a class III foil restoration until age 18 or 20 does not seem to be valid. The fact that the root ends are not completely formed in young patients means that the pulp has an increased blood supply. The bone and supporting structures of the teeth are also well adapted to repair during the growth ages. Every dentist has been amazed at the ability of a young permanent tooth to recover from severe trauma. Falls, blows, and other traumatic accidents are extremely injurious to the young permanent anterior teeth. However, a high percentage of such injured teeth recover almost uneventfully.

Kramer[2] has shown that the use of the Electro-Mallet produced only a slight disturbance in the periodontium of a dog. This would surely indicate the preference for the use of this condensing instrument. However, I have placed hundreds of class III gold foil restorations with the pneumatic condenser without the loss of any restored teeth.

I made photographs and roentgenograms of 100 individual teeth immediately before and following and then 1 year after placement of a class III gold foil filling. The root ends which were incompletely formed at the time of the operation showed normal growth at the end of 1 year. The photographs and roentgenograms showed no evidence of gingival recession or periodontal involvement at the end of 1 year. Clinical observation, pulp tests, and symptomatic reactions of the patients all indicated a normal, healthy situation. Some patients are still under observation 8 years after placement of class III gold foil restorations. To my knowledge, not a single tooth has been lost because of the class III gold foil restoration.

Some precautions must be taken in placing a class III gold foil filling in a young permanent tooth. The tooth must be supported. Green stick modeling compound is used buccally and lingually to immobilize the tooth. The rubber dam is placed to expose the cuspid distal to the prepared tooth, and the modeling compound is extended to include the cuspid and the interposed teeth. If the opposite cuspid is too far away, binding a lateral incisor to both central incisors will suffice.

Access has an important bearing on the extension of the cavity preparation. The problem of separation is solved very easily on young patients. In fact, too much separation often must be avoided. In the young patient, from 1 to 1.5 mm. of separation can be accommodated with no difficulty. The separator is adjusted slightly, and in a few minutes, the teeth usually will separate the desired amount with no further adjustment. Then, the modeling compound is placed to provide a rigid support for the tooth.

The cavity preparation is made conservatively, using the labial outline form of the inconspicuous preparation and the lingual outline form of the regular class III preparation. The ease of separation and the slight spacing of many teeth provide easy access from either the labial or the lingual direction.

The preparation in incipient cavities is one which sacrifices an absolute minimum of tooth structure. Fortunately, these cavities are the most common among young people and offer the finest opportunity for the use of gold foil. The preparation for this cavity is kept as small as possible. Only the carious area, with a minimum extension, is used for the retentive part of the preparation. The labial,

lingual, and incisal retentive points are placed within this minimal preparation, and the outline form is developed by using a long bevel. The general form of the completed preparation is saucer shaped, with the retentive portion in the central, gingival part. A small preparation with a bevel that obtains the proper outline form avoids unnecessary condensation of additional gold and conserves tooth structure.

CONCLUSIONS

Dentistry for children comprises basically merely good dental practices on younger people. The philosophy and application of proper technical procedures that have proved to be satisfactory for adult patients are certainly good for the child.

A restoration in the first molar or central incisor of a child may have to last for 70 to 80 years. This presents the dentist with a real challenge. The best he can do is not good enough.

The dentist has an added responsibility when he works on children because of the absolute dependency of the patient upon his judgment and technical skill. The little patients have no voice in the decisions made concerning their dental future. They place themselves completely under the influence of the opinions of the dentist. The dentist must regard his responsibility to them in the most serious manner and provide them with the service that will protect their health for the present and provide the best possible potential for the future.

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INDICATIONS AND CAVITY PREPARATION FOR PORCELAIN INLAYS

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RESTORATIONS for class III and class V cavities in anterior teeth frequently present difficulties for reasons of esthetics. Such problems may be solved by use of porcelain inlays. These restorations, if carefully made, are esthetic, durable, and well tolerated by both hard and soft tissues.

Fundamental design of cavity preparations for porcelain inlays has remained unchanged for many years.[1-5] Recent modifications in technique[6] enable the dentist to make use of a greater variety of cavity forms than had previously been practical. These modifications (a combination of elastic impression materials and a refractory porcelain inlay investment†) eliminate the need for a rigid die and a platinum matrix.

Since variations are usually based upon the application of sound fundamentals, it seems appropriate at this time to review the instrumentation and details of cavity form for porcelain inlays.

CLASS V

Indications.—Class V porcelain inlays are indicated in all gingival cavities where appearance is of primary importance. They are contraindicated in teeth that require extensive restoration.

Cavity Preparation.—The outline form is similar to that for a class V gold foil preparation except that the line angles are rounded (Fig. 1, *A*). It must be cleanly cut and free of irregularity.

Cutting the preparation a little more deeply than is required for gold inlays or gold foil restorations provides adequate retention. Furthermore, the surrounding walls should present as definite a box form as possible, consistent with the maintenance of sound tooth structure and extension for the prevention of recurrence of decay. The incisal and gingival walls are only slightly divergent, and the proximal walls are usually cut in a plane which approximates that of the enamel rods (Fig. 1, *A*).

The nature of porcelain requires that the cavosurface be approximately perpendicular and free of bevel (Fig. 1, *B*).

The cavity is opened and cut to its approximate form with a small plane fis-

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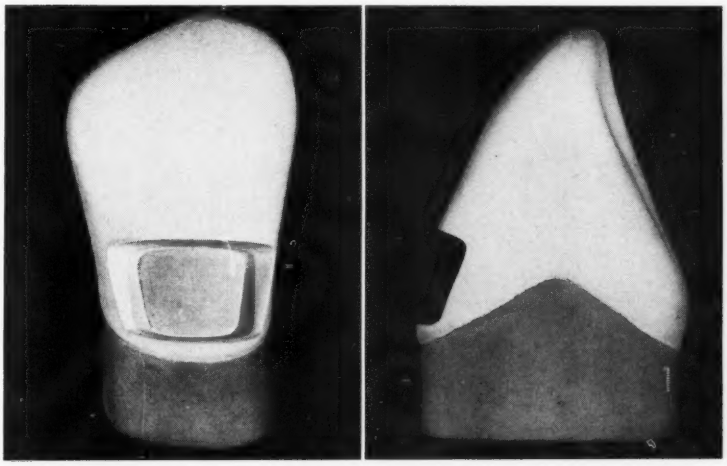


A. *B.*

Fig. 1.—A typical class V porcelain inlay preparation on a lower cuspid. *A*, Labial view. *B*, Proximal view.

sure bur in a high speed handpiece. The rubber dam and gingival clamp are placed, and the general cavity form is completed with a No. 57 fissure bur in a straight handpiece (Fig. 2). The cavity walls are defined and planed with a 10-4-8 hoe, and the cavosurface is finished with a small reverse bevel Wedelstaedt chisel.

Dependably retentive form may be difficult to obtain in large class V lesions. In these, small holes for platinum pins are cut in the axial wall (Fig. 3). The holes can best be started with a No. ½ bur, followed by a No. 700 bur to a minimum depth of 1 mm. (Fig. 4).

Not infrequently, carious involvement extends from the labial surface mesially or distally along the gingival third of the tooth. This can be included by an extension of the cavity to an area of sound tooth structure (Fig. 5).

CLASS III

Indications.—Class III porcelain inlays are indicated where esthetic appearance is of the utmost importance and where the completed preparation will not weaken the incisal angle of the tooth.

Cavity Preparation.—There are three basic types of cavity preparations; choice depends upon the extent of involvement and the approach.

Type 1, cavities of incipient nature where a separator is necessary to gain adequate access: The gingival extension is placed just under the free gingiva. The labial outline is extended to permit access for preparation and cementation. The incisal extension usually should clear the contact. The lingual extension should be minimal but into a self-cleansing area. The labial outline is in harmony with the contours of the involved tooth and the approximating tooth. The entire outline must be free of sharp angles and irregularities (Fig. 6).

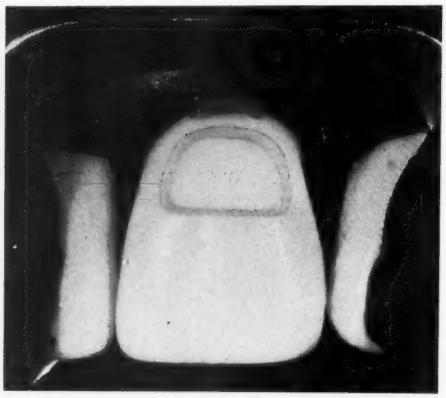


Fig. 2.—A class V porcelain inlay preparation with a rubber dam and gingival clamp in place.

The gingival and incisal walls are slightly divergent and provide the principal retentive form of this preparation (Fig. 6). The labial and lingual walls are cut in a plane approximating that of the enamel rods. The cavity is made a little deeper than is required for gold foil. The dentist must develop a definite box form while maintaining fully supported enamel walls. This is an important requirement for all porcelain inlay cavity preparations.

The cavosurface angle is cut in conformity with the enamel rods and is free of bevel.

This cavity is opened with a No. 33½ bur and a 6½-2½-9 hoe, and these same instruments are used to develop the general cavity form. The box form of the preparation is completed with a 10-4-8 hoe.

A small reverse bevel Wedelstaedt chisel is used to true the outline and finish the enamel walls.

Type 2, cavities with extensive labial involvement: The labial extension provides ease of access and, in so doing, eliminates the need for a separator (Fig. 7).

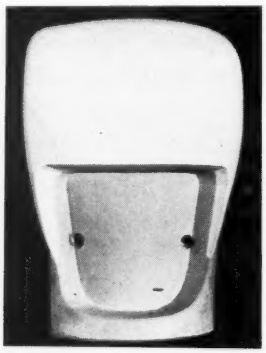


Fig. 3.—A large class V porcelain inlay preparation on an upper central incisor with pinholes for additional retention.

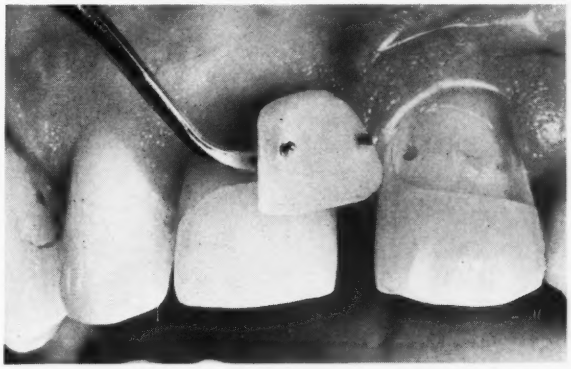


Fig. 4.—A porcelain inlay with platinum pins 1 mm. in length.

Considerable care is necessary to produce a strong, true labial cavosurface angle. Otherwise, the instrumentation and cavity form are quite typical and present no problems (Fig. 7).

Type 3, cavities requiring a lingual approach: The gingival and incisal extensions are typical (Fig. 8, *A*). The labial extension is just large enough to permit planing of the labial outline. The axial wall is flat and, at the lingual wall, forms the cavosurface of the preparation (Fig. 8, *A*).

Retention is provided by shallow, slightly divergent grooves in the dentin of the incisal and gingival walls. These extend lingually and form a conservative dovetail in the lingual outline (Fig. 8, *B*).

This cavity is cut almost entirely with a No. 700 contra-angle bur. A fine reverse bevel Wedelstaedt chisel is used to plane the labial outline. The remainder of the preparation is planed with a 10-4-8 hoe.

There are times when classes III and V cavities can be combined to advantage and a tooth thus restored with one porcelain inlay. The principal problem in such

Fig. 5.—A class V porcelain inlay preparation on an upper cuspid with extension to the proximal surface.

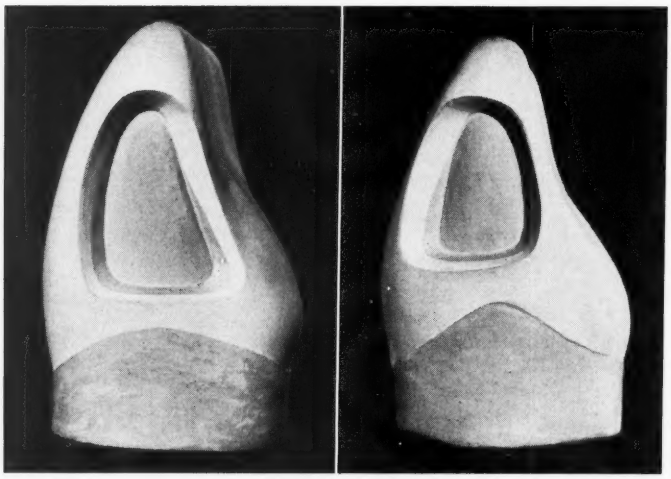


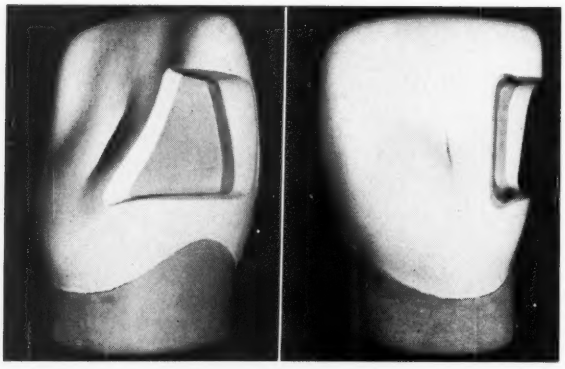
Fig. 6. Fig. 7.

Fig. 6.—A type 1 class III porcelain inlay preparation on an upper central incisor.
Fig. 7.—A type 2 class III porcelain inlay preparation on an upper central incisor.

teeth lies in developing a cavity form which permits the inlay to go into place. Prior to the beginning of preparation, the direction of draw should be carefully studied.

SUMMARY

Indications and cavity preparation for class III and class V porcelain inlays have been described. In addition, variations of these cavity preparations have been discussed. Because of the use of a combination of a refractory investment and elastic impression materials, the problem of placing durable and esthetic porcelain restorations in anterior teeth can be resolved with satisfaction.



A. *B.*

Fig. 8.—A type 3 class III porcelain inlay preparation on an upper central incisor. *A*, Linguoproximal view. *B*, Lingual view.

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IMPLANT DENTURES

A DECADE OF IMPLANT DENTURES

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I HAVE BEEN ASKED MANY TIMES, "Are implant dentures a success?" Could we not ask the same question about soft tissue–borne dentures? Generally, dentures are considered successful that have been worn for 5 years even though they may have required some adjustments.

The implantodontists are getting closer and closer to a permanent restoration as diligent research and study continue. Ninety per cent of implant dentures have been successful, including those made by hit and miss methods. More than 1,000 implant dentures are being worn today.

Most implant denture failures have been caused by a lack of knowledge of the physiologic characteristics of the bone and mucoperiosteum, improper methods of duplicating the stress-bearing areas of the bone, poor health of the patient, and the lack of an adequate interocclusal clearance and balanced occlusion.

When some implants were first made, I pointed out that because they were placed on the crest of the cancellous bony ridges and because the substructure did not accurately fit the bone, they would fail. This proved to be correct. Several years previously, I had constructed subperiosteal implants by means of direct impressions of the mandibular bony ridges. This made possible an accurate fit of the implant to the bone, and the procedure was successful.

The idea of implantation of a noncorrosive metal in the mandibular ridge to retain a prosthetic restoration came to me as I was removing an old amalgam filling that had fallen into the socket many years before. After consultation with prominent orthopedic surgeons and neurosurgeons and reading on the subject, I decided to try the idea of implanting a metal frame for supporting a denture base.

In September, 1943, a patient consented to be my experimental subject for placement of a subperiosteal implant directly on the mandible. An impression was made of the bone under difficulty because synthetic rubber impression materials were not available at the time. The records I kept before 1949 consist of paper and some drawings sent to the late Dr. George Boos in June, 1944, requesting him

Read before the Academy of Denture Prosthetics in San Juan, Puerto Rico.

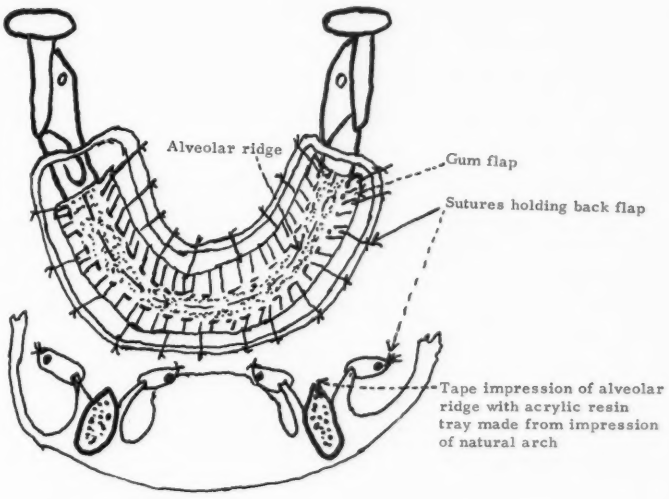
Alveolar ridge
Gum flap
Sutures holding back flap
Tape impression of alveolar ridge with acrylic resin tray made from impression of natural arch

Fig. 1.—The tracing of an original drawing made June 15, 1944, shows how the mucoperiosteum is retracted to obtain an impression of the bone.

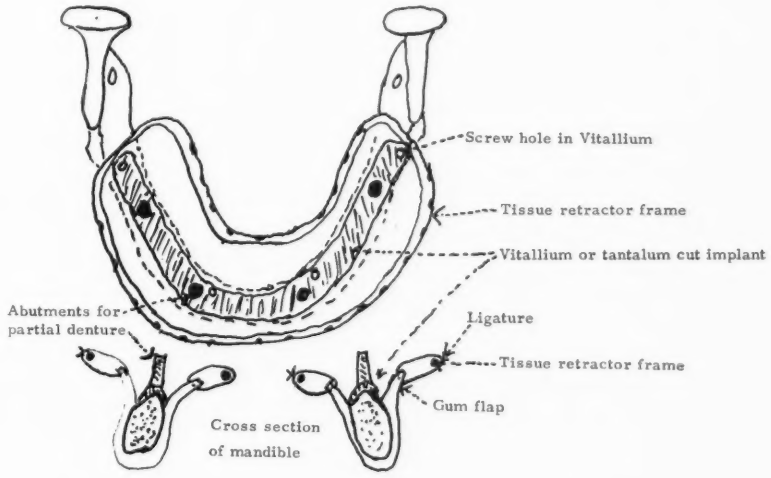

Fig. 2.—The tracing of original drawing made June 15, 1944, shows the substructure metal frame in place on the mandibular bone.

to make a casting of a subperiosteal implant (Figs. 1 and 2). These records prevented some dentists from obtaining patents for implant dentures.

The first direct technique for making an implant denture was shown before the Iowa Dental Society in May, 1949. The direct technique and an indirect technique were presented at a table clinic before the American Denture Society in Washington, D. C., in 1951. A patient wearing an implant denture was a part of the clinic.

There has been some improvement in the design of the substructure and superstructure, but they are basically the same as the first one I made. The substructure

is a noncorrosive metal casting made from an impression of the bony ridge (Figs. 3 and 4). This casting includes four vertical posts that extend up through the mucosa into the oral cavity. The substructure lies below the mucoperiosteum.

The vertical metal posts act as abutments for the superstructure (Fig. 3). The superstructure contains metal castings that fit over the four vertical posts. The superstructure is similar in outline to a removable partial lower denture base without flanges.

I discarded the use of screws and circumferential wiring of the implant several years ago. The retention is maintained by "mylohyoid ridge retainer hooks" and fixed by the use of a "stabilizer pin." Instead of the anatomically shaped posts, parallel tapering posts are used to hold the superstructure. Cuspless teeth are used instead of anatomic teeth.

My oldest living implant denture patient is 81 years of age, and he has worn the denture for 11 years. Two of my implants have been removed because of degenerative ailments. Four implants were made over because of improper design of the substructure or because the implants were inserted too soon after the extraction of the teeth.

IMPLANT DENTURE FAILURES

Failures of implant dentures are caused by (1) improper design of the substructure, (2) improper fit of the substructure to the bone, (3) trauma caused by malocclusion, (4) poor health of the patient, (5) insertion of the implant too soon after extraction, (6) excessive resorption of bone under the implant (this can be prevented by proper nutrition), (7) poor oral hygiene, (8) temporomandibular joint imbalance, (9) improper suturing of the mucoperiosteal flaps over the implant, (10) allergies, (11) torque caused by a superstructure frame distorted while curing the denture base, and (12) cuspal interference.

EXAMINATION AND PREPARATION OF THE PATIENT

Implant denture patients must be selected very carefully. The first consideration is the health of the patient. An implant denture is contraindicated for patients who show evidence of advanced degenerative disease, allergies, alcoholism, or psychosis.

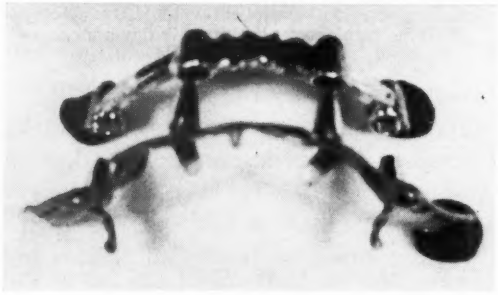

Fig. 3.—The superstructure frame above fits on the substructure which is attached to the bone.

A record is made of the patient's experiences with dentures borne on soft tissue. He is asked under what condition he lost his teeth, how long his teeth have been out, how many dentures has he worn, and his chief complaint about his dentures. An implant denture should not be started unless the teeth have been out for 2 years or more.

A thorough examination of the mouth is made. The color of the mucous membrane and the size and color of the tongue are observed. A digital examination of the lower arch is made to detect any hypersensitivity. Occasionally, the bone has resorbed to the inferior dental canal, which makes the wearing of a soft tissue–borne lower denture either difficult or impossible. Because of impaired mastication, many of these patients have malnutrition, which is reflected in the color and physiologic characteristics of the tissue of the mouth.

If the patient is accepted for implant dentures, lateral and occlusal roentgenograms of the lower dental arch and temporomandibular joint roentgenograms are made.

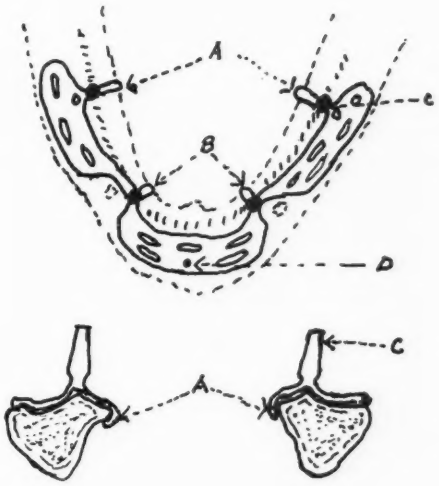

Fig. 4.—A drawing of the substructure: *(A)* the mylohyoid ridge retainers; *(B)* the stabilizer extensions; *(C)* the posts; *(D)* the stabilizer pin. Note that there are no lingual struts.

If malnutrition is a factor, the patient is placed on a high protein diet from which all white sugar and refined cereals are eliminated. Sears' book, *New Teeth for Old,* gives some excellent menus for denture patients; a copy of it is given to the patient.

Patients should not eat fresh vegetables and fruits immediately after the insertion of implant dentures because of their lack of masticatory force. Instead, juices and the nourishing foods, vitamins and minerals extracted by blenders from carrots, celery, beets, apples, grapes, oranges, cabbage, green peppers, spinach, tomatoes, etc., should be eaten by these patients. Organic vitamin and mineral supple-
for Old, gives some excellent menus for denture patients; a copy of it is given to the patient.

EQUILIBRATION OF THE TEMPOROMANDIBULAR JOINT

Equilibration of the temporomandibular joints and establishment of a physiologic rest position should be accomplished when making all prosthetic restorations (Fig. 5). The mandibular equilibration is brought about either by adjustable pivots or by quick-setting resin in the first molar regions of the patient's old dentures (Fig. 5).[1]

Physiologic rest position is located by the patient at home by opening the mouth as far as possible and letting the mandible relax to the rest position. This exercise is done several times each morning and afternoon.[2] The repositioning of the mandible and establishment of the physiologic rest position are accomplished in 3 to 6 days in most patients.

A profile record or nose-chin measurement is made on the patient's face after the mandible has assumed the physiologic rest position. The record is made by bending a piece of lead wire (wire solder) to fit the profile of the patient with the pivoted old dentures in centric occlusion. The contoured wire is placed on cardboard, and a tracing is made of the wire. A permanent profile record of cardboard results when the tracing made from the lead wire is cut out.

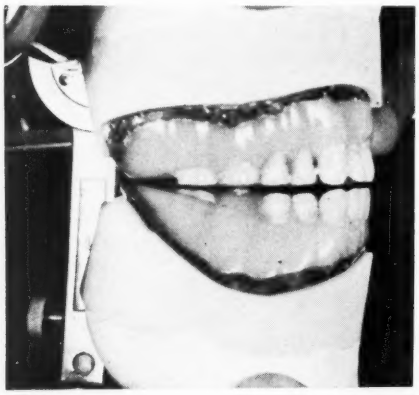

Fig. 5.—An adjustable "pivot" is used to equilibrate the temporomandibular joints.

PRIMARY IMPRESSIONS

The impression of the mandibular arch is made with modeling plastic in an oversized tray. The impression is not border molded. The external oblique ridges, the mylohyoid ridges, and the recess of the incisive fossa should be clearly defined. An implant diagnostic cast is obtained from this impression.

The maxillary impression is made in the usual manner. The procedure for registering the jaw relation records is the same as for dentures borne on soft tissue. The profile record is used to help establish the vertical dimension.

Flat plane resin teeth are used on the mandibular denture while porcelain teeth are used on the upper denture. The opposing teeth must glide smoothly over each other, especially during the healing period. The teeth *must* be checked to make certain that there are no occlusal interferences.

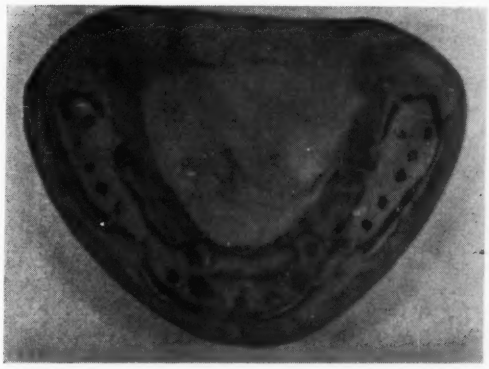

Fig. 6.—The outline for the surgical tray is made on the implant diagnostic cast.

SURGICAL IMPRESSION TRAY

The outline for the surgical impression tray is made on the implant diagnostic cast. The occlusal roentgenograms of the mandibular arch and digital examination aid in designing the tray. The occlusal roentgenogram is cut along the outline of the mandibular arch and placed over the diagnostic cast as a guide in outlining the surgical tray. The outline of the tray (Fig. 6) should include (1) the lateral borders of the external oblique ridges, (2) the mental foramina, (3) the mental protuberance, and (4) the tissue below and lingual to the mylohyoid ridges in the first and second molar regions so as to obtain an impression of the undercuts beneath the ridges. The undercuts are used to attach "mylohyoid retainer hooks" on the implant frame.

Two acrylic resin surgical trays are made on the diagnostic cast. The second tray is used to save time if the first impression is not adequate.

The upper and lower trial denture bases are tried in the patient's mouth. If

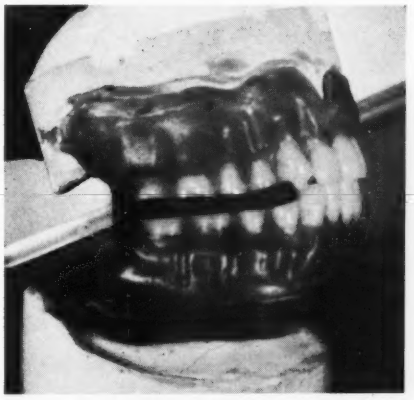

Fig. 7.—A surgical registration of the vertical dimension is made by waxing the upper and lower trial denture bases together. A ¼ inch thickness of very soft wax is added to the tissue side of the lower trial denture base. The patient is instructed to "mash" into the wax until the vertical dimension of occlusion is recorded.

the appearance and vertical and centric relations are satisfactory, the trial bases are prepared for making the jaw relation records.

The flanges of the lower baseplate are trimmed to correspond to the outline made on the diagnostic cast for the surgical impression tray. The upper and lower trial bases are waxed together in centric relation. A ¼ inch thickness of soft wax is adapted to the tissue surface of the lower baseplate (Fig. 7). The surgical jaw relation is made during the first stage surgical phase with the bases assembled in this manner.

FIRST SURGICAL PHASE

The patient is given supplemental vitamins and minerals for 1 week prior to surgical procedures. A 100 mg. dose of meperidine is administered orally 1 hour before the operation.

Local anesthesia with long duration is used to block the nerves to the mandible.

A deep Y-shaped incision is made on the retromolar pads and extended buccally over the external oblique ridges and lingually below the mylohyoid ridges. The incision is carried anteriorly along the crest of the ridge. An incision is made at the median line from the crest of the ridge to the bottom of the labial vestibule.

The mucoperiosteum is retracted buccally over the external oblique ridges from the mental foramina to the retromolar pads. Lingually, the mucoperiosteum is retracted below the mylohyoid ridges. Anteriorly, the tissue is retracted to the mental protuberance. The mental nerves or blood vessels are carefully avoided.

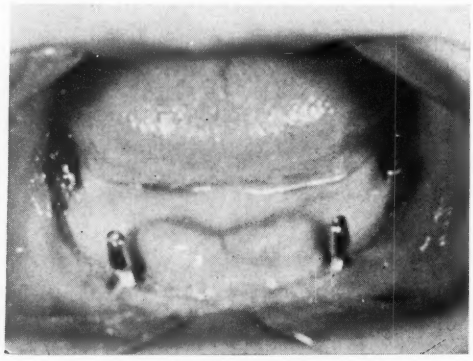

Fig. 8.—The patient, age 50, had complete dentures at 35 years of age. Four sets of dentures were worn over a 10 year period. The implant denture has been worn 5 years. The substructure is of the same design as shown in Fig. 7.

The lingual flaps are drawn back away from the bone by a "shoelace suture."[3] The flaps are held back buccally by suturing them to the inside of the cheek. The flaps are held labially by an assistant.

If there is no undercut under the mylohyoid ridge, one is made in the second molar region with a round edge diamond stone. A witness mark is made in the bone

with a surgical bur at the median line of the labial surface. This witness mark is used to locate a stabilizer pin on the finished substructure (Fig. 4). The tissue is kept wet with physiologic saline solution during the operation.

The tissue and blood are cleaned from the bone, and the prepared surgical tray containing rubber-base impression material is inserted. The impression is held securely in place until the material has set, and then it is removed.

The surgical jaw relation record is made in trial dentures that were previously prepared (Fig. 7). Denture powder is sprinkled in the upper trial base (occlusion rim), and the upper and lower trial bases are placed in the mouth. The patient is instructed to "mash" slowly into the soft wax on the lower base until the profile record fits the profile of the patient. Thus, an impression is made of the bony ridge as the patient closes the mouth into the soft wax on the lower occlusion rim.

All impression material and foreign bodies are removed from the wound. Penicillin powder is insufflated over the exposed bone, and the flaps are sutured to their original position.

Antibiotics are prescribed for some patients. Heavy doses of vitamin C aid the healing process. The dosage is 300 mg. every 4 hours.

The patient is given a printed form that instructs him to place an ice collar under the lower jaw for ½ hour, followed by warm applications for 10 minutes. This procedure is repeated every hour for 4 hours after the operation. The sutures are removed in 7 to 10 days after the operation.

DESIGNING OF THE IMPLANT FRAME

The design of the substructure is one of the most important phases of an implant denture (Fig. 4). It must be made by the dentist.

I do not use lingual struts, secondary struts over the crest of the ridge, or screws to hold the implant in place. The substructure is fastened to the mandible by mylohyoid retainer hooks and a stabilizer pin. The stress-bearing parts of the substructure frame are placed on the external oblique ridges and incisive fossa areas of the mandible and are made wide and thick in proportion to the rest of the structure.

The retainer hooks extend down lingually from the second molar posts into the natural or artifically made undercuts below the mylohyoid ridges. The substructure is sprung into place on the mandible and it holds securely. The casting is extended lingually from the cuspid posts to resist lateral stresses.

The implant cast shows the location of the witness mark at the median line in the incisive fossa. A vertical hole (parallel to the path of insertion) is drilled into the cast to a depth of 3 mm. at this mark. A stabilizer pin on the metal casting will fit in the hole (Fig. 4).

The outline of the implant frame (substructure) is designed on the cast, and both the substructure and precision-fitting superstructure are cast in Vitallium.

The superstructure is completed with acrylic resin surrounding the frame and the teeth in position. The denture base is made so that it will not impinge on the swollen tissue when the superstructure is placed on the substructure posts. After the tissue has healed, the superstructure is refitted to the mucosa.

SECOND SURGICAL PHASE

The second surgical phase is carried out about 1 month after the first operation. The premedication and incisions are the same as at the first operation, except that no incision is made at the median line. The lingual flaps are sutured back as before, but it is unnecessary to suture the buccal flaps.

The substructure is inserted on the left side first by placing the retainer hook under the left mylohyoid undercut. The right side is sprung into place so that the right retainer hook is slipped into the undercut of the right side.

The substructure frame is adjusted until the stabilizer pin is in its correct position over the previously made witness mark. (The stabilizer pin, being parallel to the path of insertion, will not be at a right angle to the bone.) A cut is made through the cortical bone at the witness mark so that the pin can be slipped into place.

Penicillin powder is insufflated into the wound before suturing. Mattress sutures are placed between the posts to divert stress from the individual sutures that hold the margins of the mucoperiosteal flaps.

After the substructure has been seated completely, the superstructure is placed on the posts. The precision fit of the superstructure frame over the substructure posts theoretically makes them one unit, and the superstructure acts as a stiffener for the substructure. There is no torque or spring to the substructure frame from masticatory forces.

The upper denture is inserted; the occlusion is observed but is not balanced until after the sutures are removed in 10 days. The patient is seen every other day until healing is complete.

Postoperative care is the same as after the first operation. The patient is instructed not to talk vigorously until after the sutures are removed because talking tends to dislodge the sutures.

The shock of these operations is much less than that which a patient usually experiences when all the teeth are extracted. There is practically no bone involvement with the implant operation, consequently the patient recovers quickly.

IMPLANT DENTURES VERSUS DENTURES BORNE ON SOFT TISSUE

The soft tissue–borne denture hastens the resorption of the residual ridge by strangulation of the blood vessels beneath the denture base. The lack of blood causes ischemic osteosis.[4] The implant denture is biologically and physiologically sound in this respect. No such occlusion of blood vessels occurs under an implant denture. The pressure exerted on the posts is transmitted directly to the bone. In these areas, the implant rests on avascular tissue. No pressure is applied on the mucosa to interfere with the normal physiologic collateral circulation that nourishes the bony foundation (Fig. 8).

An implant denture is much more stable and can support a much greater load than a soft tissue–borne denture. The psychologic effect of these advantages often gives the denture patient a new, more enthusiastic outlook.

PRESENT STATUS

Ignorance has delayed the progress of implant dentures in dentistry. Advancement has also been deterred by articles of authors who have not made a thorough study of the physiology and histology of the edentulous mandibular arch. However, after more than a decade of research and clinical experience, implant dentures have a definite place in prosthetic dentistry.

Dentists who have become skilled in the procedure have proved the desirability of placing implant dentures where they are indicated. Some of the important factors are: (1) maxillary implant dentures should be made only under extreme conditions, (2) cuspless teeth should be used to minimize horizontal forces on the implant, and (3) patients should wear dentures borne on soft tissue for about 2 years before an implant denture is constructed. Some day, the placement of implant dentures will be a common procedure for properly selected patients.

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712 Equitable Bldg.
Des Moines 9, Iowa

SURGICAL PROSTHESIS

RADIUM THERAPY APPLIANCE

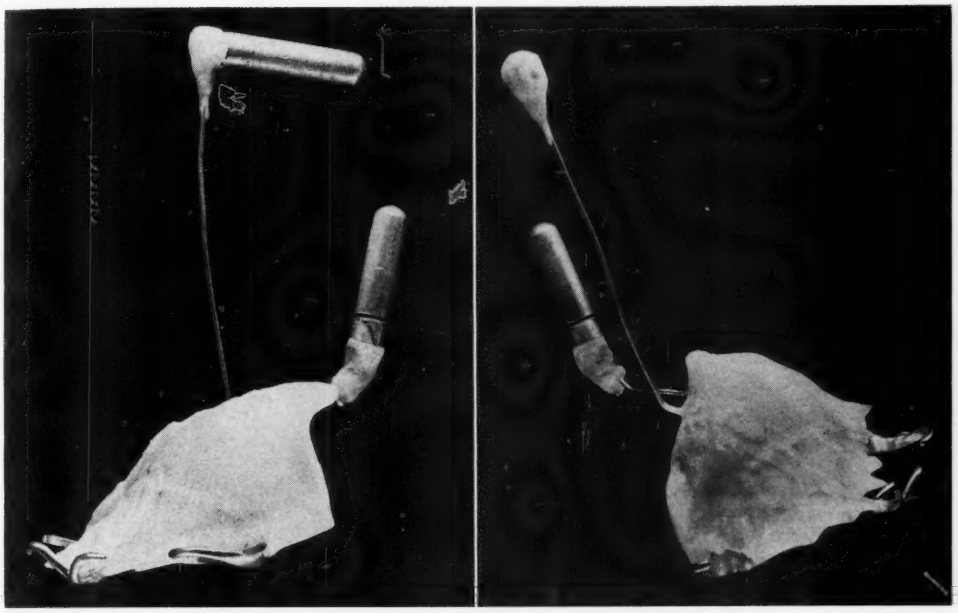
DAVID P. DOBSON, D.D.S., M.S.,* JOHN B. SOWTER, D.D.S., M.Sc.,**
WILLIAM P. WEBSTER, B.S., D.D.S.,*** AND HERBERT F. JOHNSON, M.D.****
University of North Carolina, School of Dentistry, Chapel Hill, N. C.

MANY PATIENTS MAY BENEFIT from cooperation between physicians and dentists. Restoration of mouths deformed by radical operations provides a meeting ground for medicine and dentistry.[1-4] The treatment of malignancies in the oral region provides another area for collaboration. There have been previous reports demonstrating that dentists can aid radiologists who treat tumors associated with the oral cavity.[5] This article will demonstrate how a relatively simple dental appliance facilitated radiation therapy.

A 25-year-old Negro man was referred to the North Carolina Memorial Hospital. He reported that there had been an injury to his right eye 2 months previously. Since that time, his eye had watered and had begun to protrude. He had also begun to notice a nasal obstruction on the right side. Within the previous 2 weeks, he had lost motor control of the right eye and, subsequently, his vision. He had no history of previous illnesses.

Diagnostic procedures and biopsy revealed an undifferentiated squamous cell carcinoma in the area of the right maxilla. Radical resection of the right maxilla including enucleation of the right eye was performed under general anesthesia. A microscopic evaluation of the surgical specimen revealed incomplete removal, with tumor remaining in the area of the optic foramen and the cribiform plate. The medical specialists involved felt that radiation offered the best chance to eliminate the remainder of the lesion. Radium was chosen as the method of administering radiation, in order to deliver a precalculated tumor dose[6] without exceeding a tolerable dose to the normal eye. (With a short treatment course, a cataract may be produced at approximately 350 to 550 r.,[7] and retinal damage will occur at approximately 2,500 r.)

*Professor and Head, Department of Prosthodontics.
**Associate Professor, Department of Prosthodontics.
***Research Associate in Pathology.
****Resident, Radiology, North Carolina Memorial Hospital.



A. *B.*

Fig. 1.—The prosthetic retainer with radium capsules attached. *A*, A lateral view of the appliance. *B*, An anterior view.

PROCEDURE

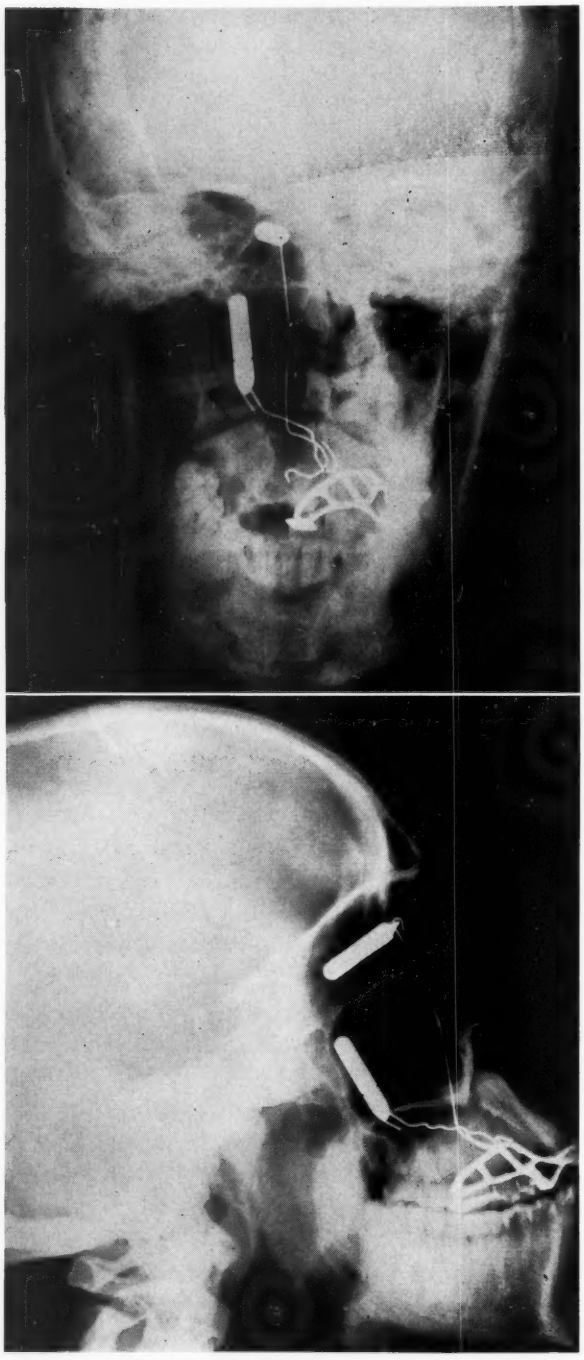
The Department of Prosthodontics was asked to construct an appliance to maintain the radium capsules in position. The original plan was to construct a bulb appliance in which the radium capsules could be inserted.[8] However, the patient could not open his mouth wide enough to allow the insertion of a large appliance.

Fortunately, the patient had a full complement of teeth in the left maxilla. It was decided to construct an appliance which could be rotated into position without requiring excessive jaw opening. It was felt that the remaining teeth would provide adequate retention for such an appliance. However, a preliminary survey revealed insufficient undercuts for this purpose.

Consequently, depressions were prepared in the enamel with suitable stones to provide retention. A final alginate impression including the remaining maxillary teeth and hard palate was made in a modified stock tray. The resulting cast was used to fabricate the base portion of the appliance. This consisted of chrome cobalt clasps and an acrylic resin palate.

The base portion was seated and tested for retention. Two pieces of 0.030 inch tempered steel wire were attached to the base with autopolymerizing acrylic resin. The radium capsules were attached to the other ends of the wires (Fig. 1). Through trial and error, the capsules were adjusted so that they would lie in the desired positions for delivering the precalculated dose to the tumor-bearing areas. The results were checked by roentgenograms (Fig. 2).

A.



B.

Fig. 2.—Roentgenograms of the head with the appliance in position. *A*, Anterior view. *B*, Lateral view.

A 20 mg. amount of radium was inserted in the superior capsule, 25 mg. in the lower capsule. The appliance was worn for 120 hours, which delivered a maximum tumor dose of 10,500 r. to the surface of the tumor-bearing area and a minimum dose of 5,250 r. to what was presumed to be the base of the tumor-bearing area.

The patient was discharged. His progress was satisfactory for 2 months after the initial operation. Four months after the operation, the patient was seen again, and he had a large swelling at the angle of the mandible. This was diagnosed as a metastatic lesion. Further radiation therapy was instituted at another hospital. Unfortunately, his condition worsened, and he died about 6 months after the original diagnosis.

DISCUSSION

The course of events following treatment was not encouraging. However, the appliance did accomplish the purpose for which it was designed. It allowed the radiologists to treat an area relatively inaccessible to external radiation or to implantation of sources of radiation. It was also possible to calculate the radiation dose to the affected area. Most important, treatment in this manner helped prevent damage to the surrounding tissue which might have caused blindness.

CONCLUSION

The use of relatively simple prosthodontic techniques provided means for carefully controlled radiation therapy. Cooperation between the medical and dental professions greatly facilitated treatment of this patient.

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READERS' ROUND TABLE

BROOKLYN, N. Y.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

In reference to the admirable paper by Dr. Schweitzer in the July-August, 1961, issue (11:625-647) of THE JOURNAL OF PROSTHETIC DENTISTRY in which he discusses the role of the transverse axes in the sagittal plane, we wish to make the following comments.

Dr. Schweitzer states, in discussing the envelope of motion in the sagittal plane, that there is hinge closure about transverse axes which lie in or very close to the condyles (page 634). This, he states, occurs in the upper part of the envelope, while the lower part of the envelope of motion represents rotation and translation about moving transverse axes. This he illustrates in Figs. 17 and 26.

These illustrations are invalid because they represent projections of the movements in the sagittal plane.

In the absence of a front view, these projections may represent distortions of true movements. This he unwittingly illustrates in Fig. 6, *B*, in which the front view shows lateral deviation of the mandible during the opening and closing movements.

The sagittal view does not show any indication of such lateral deviation.

To test for hinge closure about transverse axes in or about the condyles, a compass was used to determine the center of rotation in Fig. 17. This test disclosed that there was *no hinge closure* about transverse axes in or about the condyles.

These comments are based solely on the material presented in the article and do not necessarily represent the opinions of the writers.

Sincerely,
T. E. J. SHANAHAN, D.D.S.
ALEXANDER LEFF, D.D.S.

NEW YORK, N. Y.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

I do not agree with the criticism of Doctors Leff and Shanahan which is directed at my article, "Masticatory Function in Man." The readers must be cognizant that I am well aware of the difference in the shape of the chewing strokes in each of the three projections, otherwise I would not have constantly called attention to these differences in projections.

Figs. 17 and 26, to which they refer, represent two total envelopes of motion in the sagittal plane. Within these total envelopes are a voluntary chewing stroke and a functional chewing stroke, respectively. The posterior border line in a total envelope of movement is a single line which represents maximum mandibular retrusion. It is this line I am referring to, not the stroke within the total envelope. It is clearly shown in both the horizontal and sagittal projections in Fig. 41. There is no distortion in this projection of this border movement.

Their reference to Fig. 6, *B* is irrelevant. In this illustration, the frontal view shows voluntary masticatory strokes with no reference to the total envelope of movement. Natural chewing strokes are very likely to show lateral deviations.

In their test for hinge closure, they used a compass to determine the center of rotation. This illustration is reduced from the size of the photograph which was submitted because of the limited space available for publication. How they could possibly avoid an error in their determination is very difficult for me to see. In addition, I am not trying to defend hinge closure about a transverse axis. The literature is full of such defenses. It is generally believed that the mandible opens and closes about either one transverse axis (hinge axis) that runs through both condyles or two transverse axes that run through each condyle, respectively (hinge axes).

I am simply reporting as accurately as I can just what my records show.

Sincerely,

JEROME M. SCHWEITZER, D.D.S.

NEWS AND NOTES

MEETINGS

The Rowe Smith Memorial Foundation, Eighth Annual Seminar, Fly-n-Fish Lodge, Karnack, Texas, Nov. 30 to Dec. 3, 1961.

Greater New York Academy of Prosthodontics, Columbia University, School of Dental and Oral Surgery, 630 West 168th St., New York, N. Y., Dec. 1 and 2, 1961.

American Association of Endodontists, Fontainbleau Hotel, Miami Beach, Fla., Feb. 11 to 14, 1962.

American Equilibration Society, Blackstone Hotel, Chicago, Ill., Feb. 15, 1962. For further information, write to Dr. R. C. Van Dam, 11431 South Halsted St., Chicago, Ill.

American Prosthodontic Society (formerly American Denture Society), Congress Hotel, Chicago, Ill., Feb. 16 and 17, 1962.

The American Academy of Crown and Bridge Prosthodontics, Conrad Hilton Hotel, Chicago, Ill., Feb. 17 and 18, 1962.

The American Academy of Restorative Dentistry, Conrad Hilton Hotel, Chicago, Ill., Feb. 17 and 18, 1962.

The Southeastern Academy of Prosthodontics, Tutwiler Hotel, Birmingham, Ala., April 13 to 15, 1962.

The Academy of Denture Prosthetics, Broadmoor Hotel, Colorado Springs, Colo., April 29 to May 4, 1962.

American Association for Cleft Palate Rehabilitation, Netherland-Hilton Hotel, Cincinnati, Ohio, May 3 to 5, 1962.

Pacific Coast Society of Prosthodontics, Claremont Hotel, Berkeley, Calif., June 28 to 30, 1962.

American Society of Oral Surgeons, to be held at the Royal College, London, England, July 1 to 4, 1962. For further information, dentists and physicians in the United Kingdom and Europe may write to Dr. Terence Ward, Royal College of Surgeons, Lincoln's Inn Fields, London, W.C. 2., England; those in the United States and other countries should write to Mr. D. C. Trexler, American Society of Oral Surgeons, 840 North Lake Shore Dr., Chicago, Ill.

ANNOUNCEMENTS

Reprints of the second edition of the *Glossary of Prosthodontic Terms* are now available. Prices: 1 to 20 copies, fifty cents each; 20 to 49 copies, forty cents each; 50 to 99 copies, thirty-five cents each; 100 or more copies, twenty-five cents each. Orders for less than 100 will be mailed prepaid; orders for 100 or more will be sent shipping charges collect. Cash, check, money order, or institution purchase order *must* accompany the order for reprints; orders will not be filled otherwise. Address: Glossary Reprints, 3939 Old Brownsboro Rd., Louisville 7, Ky.

Reprints of Reports Nos. 1 and 2, "Principles, Concepts, and Practices in Prosthodontics," may be obtained by writing Dr. W. Les Warburton, Secretary-Treasurer, The Academy of

Denture Prosthetics, 807 Medical Arts Bldg., Salt Lake City 11, Utah. The price is twenty-five cents for both, with a 20 per cent discount allowed on purchases of 20 or more. Cash, check, or purchase order *must* accompany the order.

Readers of THE JOURNAL OF PROSTHETIC DENTISTRY are invited to present lectures, projected conferences, table clinics, and demonstrations on any aspect of the field of dentistry before the Federación Odontológica de Centro América y Panamá, Jan. 21 through 26, 1962, in Panama.

For further information, write to Dr. Alfredo H. Berguido, Apartado 4115, Panamá, República de Panamá.

Tufts University, Department of Periodontology, announces the establishment of a registry of gingival disease. The increasing awareness of the importance of gingival disease has created the need for a clearing house for the histopathologic evaluation of diagnostic and treatment problems. Practitioners are invited to submit gingival biopsies for diagnosis. Additional pertinent information will be provided by the registry regarding the nature of individual cases. Permanent files will be maintained for follow-up case study. There is no charge for this service.

Necessary forms and mailing containers will be sent on request by writing to Tufts University, School of Dental Medicine, 136 Harrison Ave., Boston 11, Mass.

The Dentists' Supply Company of New York has established two tuition scholarships for the school year 1961-1962 through a special grant to the Fund for Dental Education. Two additional scholarships will be established for the academic year 1962-1963. The scholarships are intended to encourage young men and women to select dental laboratory technology as a lifetime career and to assist them in acquiring the necessary training.

Applications are available from the Fund for Dental Education, the Dentists' Supply Company, or the National Association of Dental Laboratories.

The Philadelphia County Medical Society is soliciting pamphlets and resource catalogues for its library of health education literature. Contributions may be sent to Bette Metzler, Ball Associates Public Relations Agency, 845 North Broad St., Philadelphia 23, Pa.

The third edition of the annual directory and bibliography of the National Institutes of Health is available from the Public Information Section, Office of Research Information, National Institutes of Health, Bethesda, Md.

An international meeting of all those interested in psychosomatics is being arranged in order (1) to provide the opportunity for exchanging new and old formulations of inherent questions in the form of scientific reports and (2) to organize what appears to be useful for the spread of psychodontia (psychodontology) on an international level.

Inquiry is invited from any who are interested in psychodontia (psychology and psychosomatics in odontoiatry) and who might like to make a contribution on one of the following subjects: (1) psychology and psychosomatics in odontoiatry (general problems), (2) classification of the patient from the psychologic and psychosomatic points of view, (3) fear and odontophobia, (4) bad habits (thumb-sucking, bruxism, tongue movement habits) and their treatment, (5) psychodynamic dental prosthesis, or (6) hypnosis in odontoiatry.

Write to Dr. Bruno Acht, Piazzetta Umberto Giordano, 2, Milano, Italia, for further information.

The University of Pittsburgh, School of Dentistry, Graduate Division, is accepting applications for graduate study in the fields of anesthesiology, oral surgery, orthodontics, periodontics, and prosthodontics leading to the Master of Science degree. Selection of students for the fall session of 1962 will be made in March, 1962.

A nondegree, full-time, 12 month course in general anesthesia is also available for qualified dental graduates.

Graduate study in the preclinical basic sciences of anatomy, biochemistry, microbiology, pathology, pharmacology, and physiology leading to the Master of Science or Doctor of Philosophy degree is also offered through the Schools of the Health Professions. Successful applicants in this latter program are eligible for financial assistance in the form of traineeships.

For further information and application, write to Director of Graduate Education, University of Pittsburgh, School of Dentistry, Pittsburgh 13, Pa.

The University of Kansas City, School of Dentistry, is now accepting applications for graduate study in oral surgery, orthodontics, pedodontics, periodontology, prosthodontics and basic sciences for the class beginning July 1, 1962.

All specialty programs meet the academic requirements for State and National Boards. All programs may be expanded to include the Master of Science degree. A limited number of National Institutes of Health teacher-researcher fellowships are available.

For further information and application, write to Director of Graduate Studies, University of Kansas City, School of Dentistry, 1108 East Tenth St., Kansas City 6, Mo.

The University of Washington, School of Dentistry, Graduate Division, announces a graduate course in periodontics leading to a master's degree in dentistry. The training period is 2 calendar years beginning in September, 1962. Application must be made by Dec. 1, 1961, to be considered. The course is designed to develop those men qualified and interested in a future in academic dentistry.

The trainee will be supported on a stipend of $5,000 a year received from a National Institutes of Health teacher training grant. Tuition and some additional expenses will be paid as well as allowances for travel to scientific meetings.

The program is under the direction of Dr. Saul Schluger and includes advanced instruction in the basic sciences as well as the clinical and hospital disciplines. An extensive research project and thesis are reqiured.

For further information and application, write to Dr. Saul Schluger, Director, Graduate Dental Education, University of Washington, School of Dentistry, Seattle 5, Wash.

The Children's Hospital of Baltimore is accepting applications for a full-time rotating internship to begin July1, 1962. The internship will stress dentistry for the handicapped and the use of general anesthesia in complete dental service.

The training will be given with the cooperation of the Department of Pediatrics of the Johns Hopkins Hospital and is being supported by a grant from the Children's Bureau of the United States Department of Health, Education and Welfare.

For further information and application, write to Mr. C. Christiansen, Administrator, The Children's Hospital, Inc., 3825 Greenspring Ave., Baltimore 11, Md.

The Veterans Administration Medical Teaching Group Hospital of Memphis announces that one rotating dental internship and two residencies in prosthodontics will be available for the year beginning July 1, 1962.

For further information and application, write to the Chief, Dental Service, Veterans Administration Medical Teaching Group Hospital, Memphis, Tenn.

POSTGRADUATE COURSES

The University of Alabama, School of Dentistry, will present the following refresher courses:

Root Canal Therapy: Dr. Adeeb E. Thomas, Nov. 25 to 27, 1961.

Oral Cancer: Dr. Leonard Robinson, Dec. 9 to 11, 1961.

For further information and application, write to the Director, Refresher Course Program, University of Alabama, School of Dentistry, 1919 Seventh Ave., S., Birmingham 3, Ala.

Boston University, School of Medicine, Division of Graduate Studies, Department of Stomatology, announces the following postgraduate courses:

Fixed Bridge Prosthesis: Dr. Leo Talkov, Dr. David J. Baraban, and Dr. Lloyd Warshauer, Nov. 27 to Dec. 1, 1961.

Periodontal Pathology: Dr. Henry M. Goldman and Dr. Jack Bloom, Jan. 22 to 26, 1962.

The Use of Ultrasonics in Periodontal Therapy: Dr. Henry M. Goldman, March 17, 1962.

Periodontal Therapy: Dr. Henry M. Goldman, Dr. Bernard S. Chaikin, Dr. Gerald M. Kramer, Dr. William Pendergast, Dr. Jack Bloom, and associates, March 19 to 23, 1962.

For further information, write to Director of Postgraduate Studies, Department of Stomatology, Massachusetts Memorial Hospitals, 750 Harrison Ave., Boston 18, Mass.

The First District Dental Society, a component of the Dental Society of the State of New York and the American Dental Association, announces the following postgraduate courses:

Hospital Operating Room Technique for the General Practitioner: Dr. Bernard M. Cohen, Nov. 29, 1961.

A New Approach to Full and Partial Denture Construction: Dr. Jack M. Buchman and Dr. Harold Gelb, Nov. 29 and 30, 1961.

Analgesia for Modern Dentistry: Dr. Harry Langa, Nov. 30 to Dec. 2, 1961.

Bite Planes, Provisional Ligatures and Splints: Dr. Abraham Berliner, Nov. 30 to Dec. 2, 1961.

Oral Reconstruction, Emphasizing Esthetics, Using Porcelain Jackets and Porcelain Fused to Gold: Dr. Herbert H. Kabnick, Dec. 1 and 2, 1961.

Removable Precision Bridge Techniques in Reconstruction Diagnosis and the Approach Treatment: Dr. I. Franklin Miller, Dec. 12 to 16, 1961.

Advanced Thinking in Partial Denture Case Analysis: Dr. Joel Friedman, Jan. 12, 1962.

Practical Radiodontics: New Concepts and Improved Techniques: Dr. Joseph J. Martini, Jan. 24, 1962.

For further information and application, write to the Postgraduate Education Program, First District Dental Society, Statler Hilton, New York 1, N. Y.

The University of Kentucky, College of Dentistry, announces the following postgraduate course:

Periodontics for the General Practitioner: Dr. Harry M. Bohannan, Dec. 4 to 6, 1961.

For further information and application, write to Dr. Stephen F. Dachi, Director of Postgraduate Education, University of Kentucky, College of Dentistry, Lexington, Ky.

New York University, College of Dentistry, announces a course to be given in Fixed Partial Prosthesis. The course involves chair work, lectures, and demonstrations and will be given on Friday afternoons for 16 weeks beginning Jan. 5, 1962, by Prof. Edward G. Kaufman.

The College of Dentistry also announces a 2 day refresher course in endodontics, Dec. 1 and 2, 1961. Dr. Morris B. Auerback and his associates will demonstrate new developments and review current techniques in the treatment of diseases of the pulp.

For further information and application, write to Director, Postgraduate Division, New York University, College of Dentistry, 421 First Ave., New York 10, N. Y.

Northwestern University Dental School announces the following postgraduate courses:

Conference for Teachers of Dental Materials: Dr. Eugene W. Skinner and Prof. Ralph W. Phillips and associates, Dec. 4 and 5, 1961.

Functional Analysis and Treatment of the Masticatory System—For the Orthodontist: Dr. Glenn E. Jackson, Dr. John R. Thompson, Dr. Harold T. Perry, Dr. Sheldon W. Rosenstein, and Dr. John H. Konishi, Dec. 4 to 6, 1961.

Thomas L. Gilmer Memorial Lecture: Dr. Roy Storer, Jan. 17, 1962.

Functional Analysis and Treatment of the Masticatory System—For the General Practi-

tioner: Dr. Harold T. Perry, Dr. John R. Thompson, Dr. Glenn E. Jackson, and Dr. Morton S. Rosen, Jan. 22 to 24, 1962.

Basic Cephalometric Radiography: Dr. John R. Thompson, Dr. Sheldon W. Rosenstein, Dr. Earl O. Bergersen, Dr. John H. Konishi, and Dr. Raymond C. Thurow, Feb. 12 to 14, 1962.

Pedodontics: Dr. Norman H. Olsen, Dr. Howard Traisman, Dr. Frank W. Pirruccello, and Dr. Sidney I. Kohn, Feb. 15 and 16, 1962.

Basic Oral Surgery: Dr. Orion H. Stuteville, Col. Robert B. Shira, Dr. Eduard G. Friedrich, Dr. F. Robert Christopher, Dr. Benjamin J. Gans, Dr. Howard B. Adilman, and Dr. Thomas J. Starshak, March 19 to 23, 1962.

Major Oral Surgery: Dr. Orion H. Stuteville, Col. Robert B. Shira, Dr. Eduard G. Friedrich, Dr. F. Robert Christopher, Dr. Benjamin J. Gans, Dr. Howard B. Adilman, and Dr. Thomas J. Starshak, March 19 to 23, 1962.

Complete Denture Procedures: Dr. A. H. Grunewald and Dr. Bernard C. Marker, March 26 to 29, 1962.

A Practical Approach to the Use of Gold Foil: Dr. Arne F. Romnes, Dr. Eugene Bodmer, Dr. Paul H. Dawson, Dr. Eugene W. Skinner, and Dr. Clifford H. Miller, April 9 and 10, 1962.

Oral Surgery in General Practice: Dr. Orion H. Stuteville, Dr. Eduard G. Friedrich, Dr. F. Robert Christopher, Dr. Benjamin J. Gans, Dr. Howard B. Adilman, and Dr. Thomas J. Starshak, April 9 to 13, 1962.

Orientation for Hospital Dental Service: Dr. Eduard G. Freidrich, Dr. George W. Teuscher, Dr. Orion H. Stuteville, Dr. Frederick N. Elliott, Dr. Gerald J. Casey, and Dr. Mary Karp, April 25 to 27, 1962.

Edmund Noyes Memorial Lecture: Dr. Don W. Gullett, May 2, 1962.

Endodontics: Dr. Michael A. Heuer, Dr. Harold Gerstein, and Dr. William H. Clem, May 7 and 8, 1962.

Current Concepts in Operative Dentistry: Dr. Arne F. Romnes, Dr. Eugene Bodmer, Dr. Wilmer B. Eames, Dr. Eugene W. Skinner, and Dr. Richard N. Lamermayer, May 14 to 16, 1962.

Conference for Teachers of Pedodontics, June 4 and 5, 1962.

Advanced Cephalometric Radiography: Dr. John R. Thompson, Dr. Glenn E. Jackson, Dr. Sheldon W. Rosenstein, Dr. Earl O. Bergersen, Dr. Frank S. Ryan, and Dr. B. Holly Broadbent, June 24 to 26, 1962.

For further information and application, write to Northwestern University Dental School, 311 East Chicago Ave., Chicago 11, Ill.

The Ohio State University, College of Dentistry, announces the following postgraduate courses:

Oral Surgery: Dr. Morgan L. Allison, Nov. 27 to 29, 1961.

Hospital Management for Dental Procedures: Dr. Morgan L. Allison and Dr. Bernard S. Snyder, Jan. 22 to 24, 1962.

Clinical Periodontics: Dr. John R. Wilson and Dr. William V. Walton, Jan. 25 to 27, 1962.

A Refresher Course in Dental Hygiene: Dr. Consuelo Wise and Dr. John R. Wilson, Jan. 29 and 30, 1962.

Crown and Bridgework: Dr. Thomas F. McBride and Dr. Alfred C. Long, Jan. 31 to Feb. 2, 1962.

Pedodontics and Interceptive Orthodontics: Dr. Lyle S. Pettit and Dr. Benjamin H. Williams, Feb. 5 to 9, 1962.

Complete Denture Prosthodontics: Dr. Carl O. Boucher, Feb. 26 to March 2, 1962.

Removable Partial Denture Prosthodontics: Dr. Victor L. Steffel, March 5 to 9, 1962.

Hypnosis in Dentistry: Dr. Charles M. Pfersick, April 2 to 4, 1962.

Endodontics: Dr. J. Henry Kaiser, April 9 to 13, 1962.

General Anesthesia: Dr. Morgan L. Allison, April 23 to 27, 1962.

Dental Drugs in Action: Dr. W. Russell Kampfer, April 27 and 28, 1962.

Elastic Impression Materials and Technics: Dr. Thomas F. McBride and Dr. Donald W. Dickson, May 2 and 3, 1962.

Oral Surgery: Dr. Morgan L. Allison, May 7 to 9, 1962.

For further information and application, write to the Ohio State University, College of Dentistry, 305 West Twelfth Ave., Columbus 10, Ohio.

The University of Pennsylvania, School of Dentistry, announces the following postgraduate courses:

Dentistry for Handicapped Children: Dr. Manuel M. Album and associates, Nov. 20 to 22, 1961.

Dermatologic Lesions With Oral Manifestations: Dr. Jens J. Pindborg of Copenhagen, Denmark, Nov. 27 and 28, 1961.

Seminar on Handicapped Problems: Dr. Manuel M. Album and associates, Nov. 30, 1961.

Periodontal Therapy: Dr. Henry M. Goldman and Dr. D. Walter Cohen, Dec. 11 to 15, 1961.

The Use of Ultrasonics in Periodontia: Dr. Henry M. Goldman and Dr. D. Walter Cohen, Dec. 16, 1961.

Oral Pathology: Dr. Lionel Gold and associates, 1 day per week, Jan. 6 through March 17, 1962.

Periodontal Histopathology: Dr. Henry M. Goldman, Dr. D. Walter Cohen, and Dr. Frederic M. Chacker, Jan. 8 to 12, 1962.

Practical Procedures of Oral Rehabilitation. Part I: Dr. Ernest R. Granger, Dr. William Maxwell, and Dr. Robert Simpson, Jan. 15 to 19, 1962.

Orthodontic Treatment Planning and Associated Appliance Therapy: Dr. William L. Wilson, Jan. 22 and 23, 1962.

Cephalometry: Dr. Viken Sassouni, Jan. 22 to 25, 1962.

Impacted Teeth: Dr. Victor H. Frank and associates, Jan. 24 to 26, 1962.

Periodontal Prosthesis: Dr. Morton Amsterdam, Dr. D. Walter Cohen and associates, Feb. 5 to 9, 1962.

Partial Dentures: Dr. M. M. DeVan and associates, Feb. 26 to March 2, 1962.

Practical and Simplified Procedures in Crown and Bridge Prosthesis: Dr. Charles B. Sceia, March 12 to 16, 1962.

Emotional Significance of the Teeth and Oral Cavity: Dr. Nathan Friedman, March 31, 1962.

Practice Administration: Dr. Harry M. Klenda, April 2 and 3, 1962.

Complete Denture Prosthesis: Dr. M. M. DeVan and associates, April 2 to 6, 1962.

Advanced Course in Periodontal Therapy: Dr. Henry M. Goldman and Dr. D. Walter Cohen, April 9 to 13, 1962.

Practical Procedures of Oral Rehabilitation. Part II: Dr. Ernest R. Granger, Dr. William Maxwell, and Dr. Robert Simpson, April 23 to 27, 1962.

Endodontics: Dr. Louis I. Grossman and associates, April 23 to May 4, 1962.

Review on Occlusion: Dr. Ernest R. Granger, Dr. William Maxwell, and Dr. Robert Simpson, April 27, 1962.

Minor Tooth Movement and Temporary Stabilization: Dr. Leonard Hirschfeld, May 2 to 4, 1962.

Refresher Course in Periodontal Therapy: Dr. Henry M. Goldman, Dr. D. Walter Cohen, and Dr. Morton Amsterdam, May 5, 1962.

The Thirteenth Mid-Atlantic States Conference on Dentistry: Dr. Morton Amsterdam, Dr. Henry M. Goldman, Dr. Arthur E. Kahn, Dr. Lindsey D. Pankey, Dr. Laszlo Schwartz, and Dr. Harry Sicher, May 6 to 11, 1962.

Complete Denture Prosthesis Seminar (Continuation): Dr. M. M. DeVan, May 17, 1962.

Biologic Aspects of Endodontics: Dr. Samuel Seltzer and Dr. I. B. Bender, May 21 to 25, 1962.

The Twin Wire Mechanism: Dr. Joseph E. Johnson, June 4 to 8, 1962.

Endodontics—Immediate Root Resection: Dr. Louis I. Grossman and associates, June 11 to 15, 1962.

Orthodontics for the General Practitioner: Dr. Robert E. Moyers and associates, June 18 to 22, 1962.

For further information and application, write to Director of Postgraduate Courses, University of Pennsylvania, School of Dentistry, 4001 Spruce St., Philadelphia 4, Pa.

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High Speed in Operative Dentistry: Dr. Carlos Weil and Dr. Charles A. Nagle, Dec. 13, 1961.

Implant Dentures: Dr. Aaron Gershkoff and Dr. Norman I. Goldberg, Jan. 8 to 12, 1962.

Periodontal Prosthesis: Dr. Morton Amsterdam and Dr. D. Walter Cohen, Feb. 5 to 9, 1962.

Pedodontics for the General Practitioner: Dr. Ernest F. Ritsert, Feb. 12 to 16, 1962.

Practice Administration: Dr. Jay H. Eshleman, Feb. 17, 1962.

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Electronic Electrosurgery: Dr. Maurice J. Oringer, March 7 and 8, 1962.

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Immediate Surgical Endodontics: Dr. Leonard Parris, Dr. Harold Rappaport, and Dr. Robert Uchin, April 2 to 6, 1962.

Advanced Surgical Techniques in Periodontal Therapy: Dr. Saul Schluger and Dr. Jack Alloy, April 9 to 13, 1962.

Full Denture Seminar (Special One-Day Refresher Course): Dr. Bernard Jankelson, May 5, 1962.

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Graduate Orthodontics: Dr. Robert B. Hedges and associates, per semester.

For further information and application, write to Dr. Louis Herman, Director of Postgraduate Studies, Temple University, School of Dentistry, 3223 North Broad St., Philadelphia 40, Pa.

The University of Tennessee, College of Dentistry, announces the following postgraduate courses:

Full Denture Prosthesis, Nov. 29 and 30, 1961.

Hospital Dentistry, Feb. 5 to 7, 1962.

Role of the Dentist in the Management of Oral Cancer, Feb. 7 to 9, 1962.

Dental Therapeutics, Feb. 21 to 23, 1962.

Endodontia, Feb. 28 to March 2, 1962.

Dental Hygiene, April 4 to 6, 1962.

Fixed Partial Prosthodontics, April 9 to 11, 1962.

Evaluation—Clinical Materials, April 18, 1962.

Surgical Endodontia, June 13 to 15, 1962.

For further information and application, write to Dr. Wallace H. Mayton, Director, Postgraduate Department, University of Tennessee, College of Dentistry, 62 South Dunlap St., Memphis 3, Tenn.

Tufts University, School of Dental Medicine, announces the following postgraduate courses:

Hospital Management of the Dental Patient: Dr. Richard Taylor and dental department, Feb. 7 to 9, 1962.

Crown and Bridge Design and Construction: Dr. Frank A. Eich, Feb. 15 and 16, 1962.

A Participation Course in Applied Anatomy of the Head and Neck: Dr. Alton D. Brashear and dental department, Feb. 28 to March 2, 1962.

Orthodontic Principles of Interest to the General Practitioner: Dr. Shapiro, Dr. Mendeloff, and Dr. Field, 6 Wednesdays, all day, Feb. 28 to April 4, 1962.

Complete Mouth Rehabilitation Through Fixed Partial Denture Prosthodontics: Dr. Harry Kazis and Dr. Albert J. Kazis, 6 Wednesday afternoons and evenings, Feb. 28 to April 4, 1962.

The Diagnosis, Management and Therapy of Lesions of the Oral Mucosa: Dr. Philip McCarthy, Dr. Francis P. McCarthy, and Dr. Gerald Shklar, 8 consecutive Wednesdays, March 7 to April 25, 1962.

Surgical Pathology of the Mouth and Jaws: Dr. Irving Meyer, Dr. Gerald Shklar and staff, 8 Thursdays, March 8 to May 10, 1962.

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Yeshiva University, Albert Einstein College of Medicine, Department of Dentistry, announces the following postgraduate courses:

Clinical Photography: Dr. Eugene B. Blanck, Nov. 16 and 17, 1961.

Endodontics: Dr. Julius Fox, Nov. 29, 1961.

Prosthetics (Oro-facial Prosthetics): Dr. Lester E. Rosenthal, Dr. Max A. Pleasure, Dr. Stanley L. Lane, and Dr. Milton Ivker, Nov. 30 and Dec. 1, 1961.

Pharmacology (Practical Use of Drugs in All Phases of Dentistry): Dr. Stanley R. Spiro and associates, Jan. 25 and 26, 1962.

Endodontics: Dr. Julius Fox and associates, Thursdays, Feb. 22 and March 1 and 8, 1962.

Periodontics (Participation Course): Dr. Marvin N. Okun, Dr. Irving Yudkoff, and associates, 10 Wednesdays, Feb. 28 through May 2, 1962.

Prosthetics (Full Denture Construction): Dr. Lester E. Rosenthal and Dr. Max A. Pleasure, Fridays, March 2 through 30, 1962.

Preventive Orthodontics and Minor Tooth Movement: Dr. Frank Kanter and associates, April 6 and 13, 1962.

Anesthesiology (Pain Control Through Modern Analgesia in Dentistry): Dr. Stanley R. Spiro and associates, April 12 and 13, 1962.

Dental Alveolar Surgery: Dr. William Rakower, Dr. Herbert Calman, Dr. Stanley J. Behrman, and associates, May 3 and 4, 1962.

For further information and application, write to Director, Postgraduate Dental Division, Yeshiva University, Albert Einstein College of Medicine, Eastchester Rd. and Morris Park Ave., Bronx 61, N. Y.

ERRATUM

In the article "Factors Contributing to Traumatic Occlusion" by Clyde H. Schuyler in the July-August, 1961, issue of this JOURNAL, Fig. 3 (p. 711) and Fig. 5 (p. 713) are transposed. The legends are correct.

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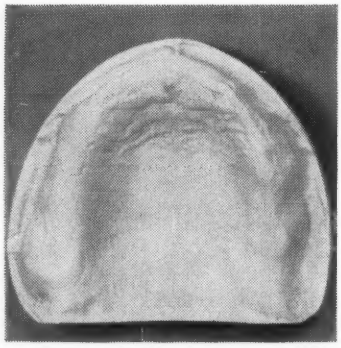

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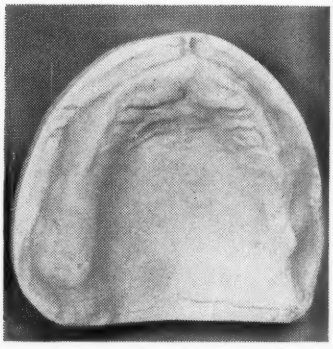

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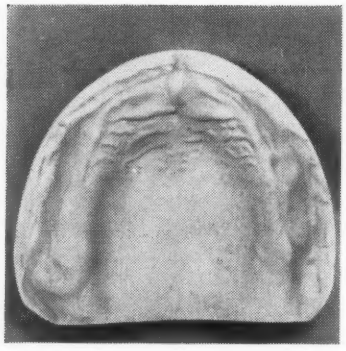

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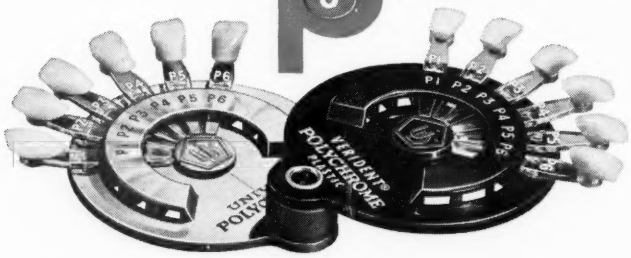

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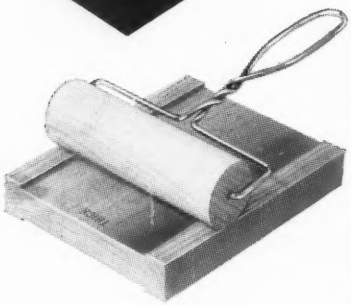

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1 Spatula.....	1.70
1 4 oz. Solitine.....	1.70
Total List Price	$19.80

SPECIAL KIT PRICE ALL FOR $17.80

YOU WILL SAVE $2.00 AND GET THE KERR ROLLETTE FREE

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Rollette rolls Formatray to just the proper thickness to form the tray.

Formatray custom built tray ready for taking full denture impression with Permlastic.

Complete Permlastic Full Denture Impression.

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...for your enthusiastic approval of our PORCELAIN JACKETS, as evidenced by the unprecedented volume of your orders. Your patronage is deeply appreciated. It has been a pleasure to serve you, and we pledge our best efforts to merit your continued confidence in our product and service.

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A WORD TO YOU OTHER DOCTORS WHO
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There must be a REASON for the overwhelming preference for our product, expressed by your fellow dentists. Don't miss out on a good deal! We invite you to experience for yourself, the superior workmanship that goes into our PORCELAIN JACKETS. You, too, will appreciate the DIFFERENCE! Mail the coupon below today!

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Two Famous Names in Dentistry

DR. HORACE H. HAYDEN
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Dr. Hayden and Dr. Harris together organized the Baltimore College of Dentistry, the first school for the specific education of dentists — a major step in advancing dentistry to the status of a separate and distinct profession.

another famous name in Dentistry. . . .

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From **VERNON-BENSHOFF,** leaders in the field of quality denture materials, come the two completely compatible products — **VERNONITE and VERNO-SOFT.**

They complement each other . . . making cushioned dentures . . . **VERNONITE** providing the hard base for strength . . . **VERNO-SOFT,** the soft lining for comfort.

And being members of the same family of resins, **VERNONITE and VERNO-SOFT** really stick together. Together they form an inseparable molecular bond.

For performance that will please and ease your patient . . . prescribe **"VERNO-SOFT on VERNONITE".**

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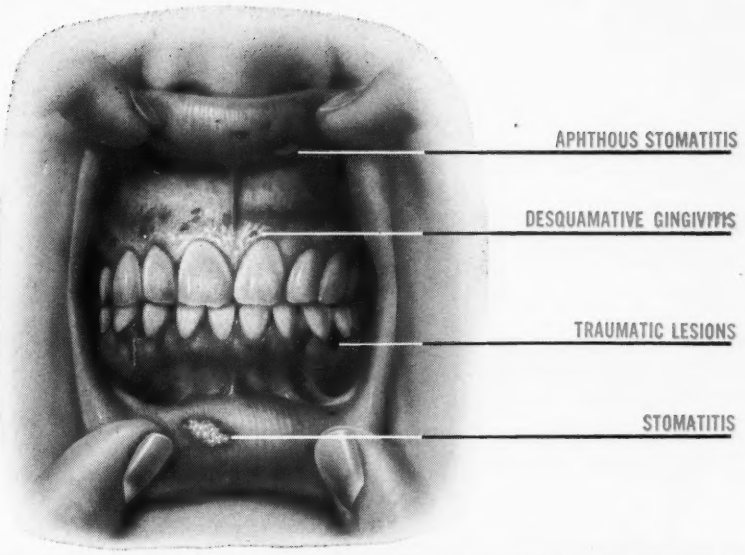
NEW!

the first truly specific topical anti-inflammatory treatment for acute and chronic oral lesions



Kenalog in Orabase

Squibb Triamcinolone Acetonide in Emollient Dental Paste

a product of Squibb Research in Dentistry

clinically proved[1-3] ***in*** **aphthous stomatitis • denture stomatitis • erosive lichen planus • recurrent ulcerative stomatitis • desquamative gingivitis • stomatitis • and in a wide range of traumatic lesions, such as denture sore spots.**

Kenalog in Orabase is an entirely new kind of preparation that provides a unique dual approach to the topical treatment of acute and chronic lesions of the oral mucosa. It combines a highly effective anti-inflammatory agent, Kenalog (Squibb Triamcinolone Acetonide)—a steroid regarded as possessing superior clinical effectiveness—with a new, soothing adhesive/emollient paste, Orabase. Relief is prompt. Because Orabase adheres firmly to moist oral tissues, the anti-inflammatory benefits of Kenalog are sustained. Even acute, traumatic lesions usually heal promptly.

Kenalog in Orabase is tasteless, odorless. It is supplied *only on prescription* in 5 Gm. tubes, with each Gm. providing 1 mg. of Squibb Triamcinolone Acetonide.

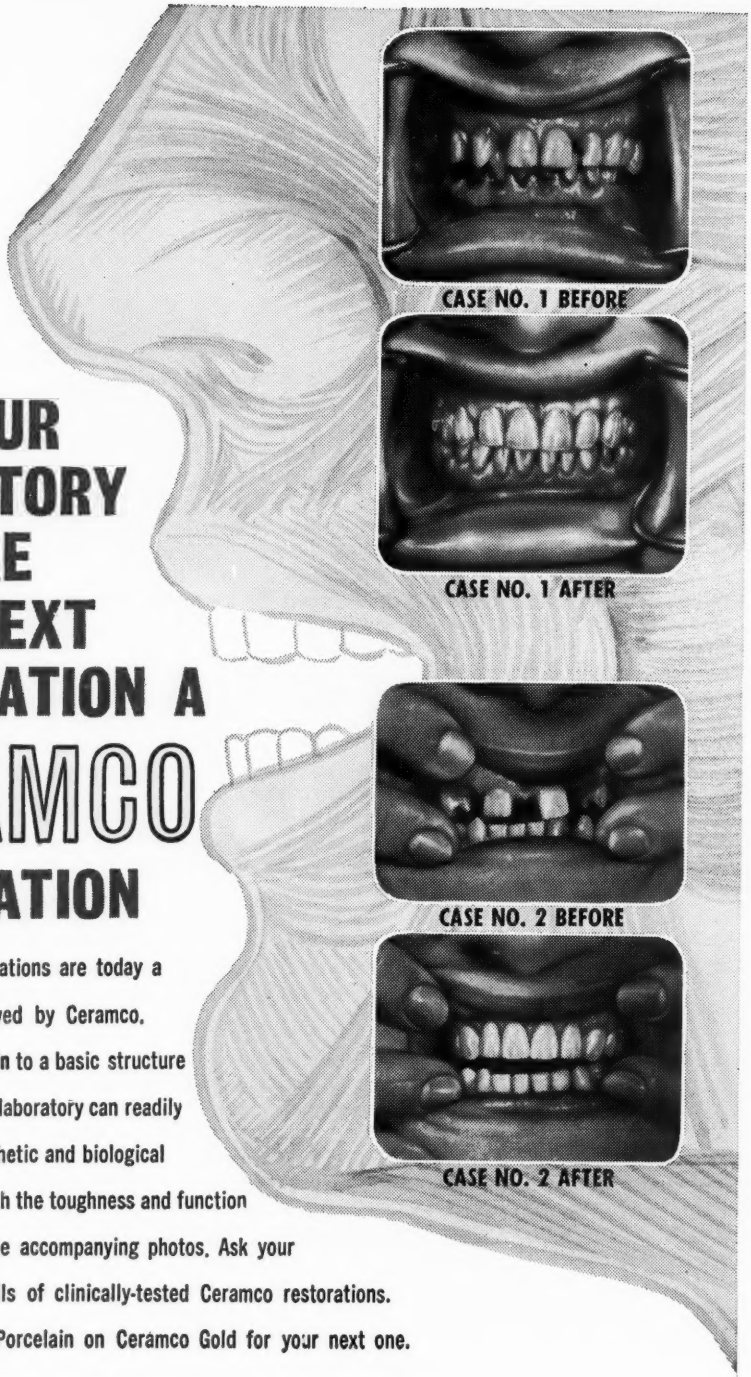
comments on safety: When Kenalog in Orabase is used as recommended systemic effects are most unlikely. Local reactions have been observed only rarely. However, when the dental patient has tuberculosis, peptic ulcer or diabetes, consultation with the patient's physician should precede treatment with any steroid agent. The use of any topical steroid is contraindicated in herpetic lesions of known viral origin such as herpes labialis, intraoral lesions, such as primary herpetic stomatitis, and herpanginas. For complete information, consult package insert or write, Professional Service Department, Squibb, 745 Fifth Avenue, New York 22, N. Y.

'Kenalog'® and 'Orabase' are Squibb trademarks.

SQUIBB

Squibb Quality—
the Priceless Ingredient

References: 1. Zegarelli, E. V., and others: Oral Surg. *13*:170 (Feb.) 1960. 2. Zegarelli, E. V.; Kutscher, A. H., and Silvers, H. F.: J. Periodontol: *30*:63 (Jan.) 1959. 3. Katz, E.; Zegarelli, E. V., and Kutscher, A. H.: Ann. Dent. *19*:40 (June) 1960.



ASK YOUR LABORATORY TO MAKE YOUR NEXT RESTORATION A CERAMCO RESTORATION

Porcelain-on-gold restorations are today a practical reality—achieved by Ceramco. Fusing **Ceramco Porcelain** to a basic structure of **Ceramco Gold***, your laboratory can readily combine for you the esthetic and biological benefits of porcelain with the toughness and function of gold as shown in the accompanying photos. Ask your laboratory for full details of clinically-tested Ceramco restorations. Then specify Ceramco Porcelain on Ceramco Gold for your next one.

CERAMCO, INC., 34-35 56th St., Woodside 77, New York

CERAMCO

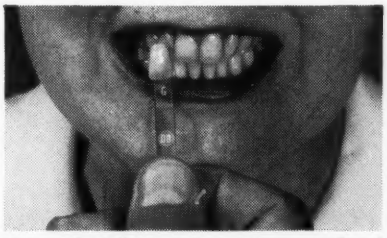
*Ceramco Gold is manufactured solely by Julius Aderer, Inc. and J. F. Jelenko & Co., Inc.

Myerson's Dura-Blend Teeth Provide Accurate Shade Matches for Partial Cases

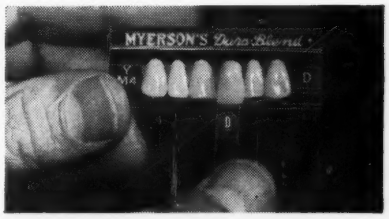
The success of even the best made partial denture depends on how well you match the natural teeth in the patient's mouth. Therefore, only teeth offering the utmost in shade accuracy and naturalness should be considered in partial work.

6 Ways that Dura-Blend Shade Accuracy is Important to Your Practice

1. Recent tests demonstrate that the Dura-Blend shade guide matches natural teeth three times as often as the nearest competitive shade guide.
2. Dura-Blend teeth provide the greatest consistency to their own shade guide.
3. Shades are consistent from batch to batch. No matter when Dura-Blend teeth were made, they will match your Dura-Blend shade guide.
4. The shade match you secure at the chair will remain a match in any light: daylight, fluorescent, or incandescent.



Dura-Blend shade guide matches natural teeth three times as often as the nearest competitive shade guide.



Dura-Blend teeth provide the greatest consistency to their own shade guide.

5. Dura-Blend shade guides are consistent with each other. Your shade guide will match your laboratory's shade guide.
6. Dura-Blend resin teeth match Myerson's porcelain teeth so well that you can use any desired combination.

The translucency and surface lustre of natural teeth are duplicated in Dura-Blend resin teeth. They harmonize so well with adjacent natural teeth that they proved 89% undetectable by dentists in tests conducted at state dental meetings.

Superior Durability

Dura-Blend teeth were the first to be made of cross-linked co-polymer resin. Their superior durability, proven in millions of successful cases during the past 13 years, has not yet been equalled.

If you don't have a Dura-Blend shade guide, write to:

Myerson Tooth Corporation
92 Hamilton Street, Cambridge 39, Mass.

IN TODAY'S BUSY PRACTICE . . .

every second counts

There are just so many hours to see your patients—no additional hours to see more patients. Now the ratio of population to dentist is 1900 to one. Vitallium restorations can conserve your chairtime, particularly if you have been experiencing extra-long appointments, adjustment appointments, repair appointments or remake appointments.

To save every second of your valuable chairtime, prescribe Vitallium quality service.

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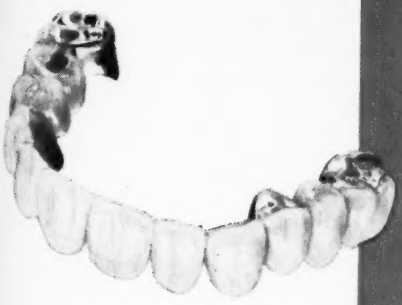
The finest
PRECIOUS METAL
restoration

now
VACUUM FIRED
for improved
natural appearance



Micro-Bond porcelain fused to precious metal crown and bridgework provides the ultimate in beautiful, natural appearance and long, useful service, especially for young patients. Vacuum fired for exceptional strength and improved color matching.

P Micro-Bond® P

A new motion picture film on Micro-Bond, "Designed for Beauty", is available for clinics, study clubs and local dental society meetings. Contact your Micro-Bond laboratory, or Scientific Film Company, 909 E. 31st Street, LaGrange Park, Illinois.

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PORCELAIN OR PLASTIC ?

PORCELAIN OR PLASTIC ?

PORCELAIN OR PLASTIC ?

PORCELAIN OR PLASTIC ?

PORCELAIN OR PLASTIC ?

Now, Doctor, for the first time in the history of full denture procedure you may choose plastic teeth with assurance and confidence.

Kenson *Ceramatype* (plastic) Multichromatic Anteriors permit you to predetermine accurately the end result you desire in any specific full denture case.

If your diagnosis points up the feasibility of duplicating the crown form depth of the extracted natural upper incisors, you may replace these important dimensions with *Ceramatype* natural reproduction anteriors. Conversely, this is impossible with porcelain upper anteriors because the impediment of pin retention precludes natural crown formation. *Ceramatype* full crown forms deliver these advantages not obtainable in porcelain:

- **More Natural "feel"** • **Greater tongue room**
- **Better lip support** • **Improved phonetics**

If you have been favorably attracted to the modern concept of multiple blending now available in all better porcelain anteriors, you'll find the multichromatic optical effect in *Ceramatype* more pleasing and more natural.

Ceramatype's six basic blends deliver the subtle highs and lows of natural tooth colors. The harsh contrasts often apparent in porcelain, resulting from several divergent color layers, do not appear in *Ceramatype*.

Ceramatype blends, produced by Kenson's exclusive pressure injection molding process offer these advantages over porcelain:

- **Less "grey-out" or "grey-down" under oral cavity shadowing**
- **Devoid of ugly markings often objectionable to patients**
- **More subtle vitality**

NOTE: *The whims of older female patients who insist on the cosmetic effect of light teeth, may be met at your discretion with Ceramatype, without violating natural appearance.*

Ceramatype delivers several bonus features, not available in porcelain, which assist patient comfort:

- **Less weight** • **Less ridge hardship** • **Less noisy clicking**
- **No ugly unsanitary seepage at gingival areas**

Ceramatype anteriors are molded by Kenson's exclusive ram injection system. Unlike conventional compression molded plastic teeth, this pressure process delivers to Kenson Plastic Teeth the superior properties of mouth endurance and rugged wear. Thousands of actual Kenson Tooth case histories throughout the U.S. and Canada during the past six years testify to these facts. These case histories likewise have proven that *Ceramatype* delivers two important mouth endurance factors not available in porcelain:

- **Less chippage and tooth breakage**
- **Less denture breakage, because *Ceramatype* welds to the base material and thus increases the overall arch strength of the denture**

Please consult your local or area Kenson Dental Laboratory for detailed *Ceramatype* information, or write Kenson for the brochure "*Ceramatype* Facts."

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Factory & Research
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now . . .
treat the whole pain problem
pain, anxiety, tension

TABLETS

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EQUANIL® (Meprobamate, Wyeth) and ZACTIRIN®
(Ethoheptazine Citrate with Acetylsalicylic Acid, Wyeth)

EQUAGESIC effectively relieves pain, anxiety, and muscle spasm—the symptom complex most commonly displayed by dental patients.

stops pain—Clinical studies[1-3] prove that the analgesic in EQUAGESIC relieves pain of dental infection, postoperative and postsurgical pain.

relieves anxiety and muscle spasm—EQUAGESIC contains meprobamate which relieves anxiety and muscle tension or spasm, such as occurs in functional temporomandibular joint disease.[4]

References: 1. Rankin, K.R.: Dental Digest *65*:356 (Aug.) 1959. 2. Albertson, G.L.: Oral Surg., Oral Med., and Oral Path. *12*:438 (Apr.) 1959. 3. Irby, W.B., and Baldwin, K.H.: Dental Survey *34*:1456 (Nov.) 1958. 4. Shore, N.A.: J. Prosthetic Dentistry *10*:366 (March-Apr.) 1960.

For further information on limitations, administration and prescribing of EQUAGESIC, see descriptive literature or current Direction Circular.

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Wyeth
SERVICE TO DENTISTRY

You're Missing Something

A. *Hygiene*

Luxene denture base material and Luxene teeth combine chemically. This produces a sanitary denture which excludes the infiltration of bacteria between the teeth and the base.

B. *Strength and Stability*

The Luxene All-Vinyl Denture provides the highest standards of toughness, and chemical and dimensional stability. Clinical reports reveal practically no breakage of the base or the teeth.*

LUXENE

LUXENE INC.

IF YOU HAVEN'T PRESCRIBED

Luxene *All-Vinyl Dentures*

C. *Esthetics*

The Luxene All-Vinyl Denture will give you and your patient what you are both looking for — a restoration that is completely natural in appearance.

To provide a wide range of selection, Luxene Teeth are available in 24 lifelike shades. Request a Luxene Shade Guide from your Luxene Processing Laboratory.

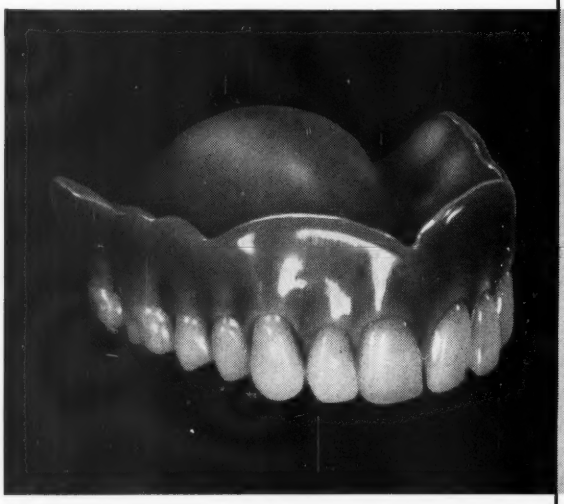
The time-tested superiority of the Luxene All-Vinyl Denture has been established over a 20 year period by patient and professional satisfaction.

LUXENE VINYL RESIN is an exclusive product of the dental profession. It has no other commercial uses. The quality standards which it maintains under all mouth conditions are consistent with the profession's standards for dental health.

*NOVEMBER 1960 JADA: "Clinical Observations of Number of Fractures of Acrylic and Modified Copolymer Vinyl Dentures"; William F. D. Grant, D.D.S., department of dentistry and oral surgery, Henry Ford Hospital.

NEW YORK

LASTING AND LIFE-LIKE



S. S. WHITE DENTURE ACRYLIC

FOR FULL AND PARTIAL RESTORATIONS

EXCELLENT WORKING QUALITIES AND FINISHING PROPERTIES FOR TROUBLE-FREE RESULTS

PERMANENT COLOR FOR NATURAL LUSTROUS APPEARANCE . . . EASY TO KEEP CLEAN

SAFE AND COMFORTABLE. NO TOXINS OR IRRITANTS

RESISTS ABRASION AND THE SOLVENT EFFECT OF FOODS AND BEVERAGES

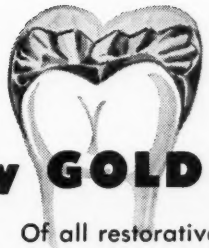
EASY TO PROCESS . . . NO PITTING OR WARPING

COMPLETE DIMENSIONAL STABILITY IN THE MOUTH

For the denture base that assures complete satisfaction,
from dentist to patient, use S. S. White Denture Acrylic.

Complies with A.D.A. Specification No. 12

THE S. S. WHITE DENTAL MFG. CO.
Philadelphia 5, Pa.



why GOLD inlays?

Of all restorative materials or methods for the preservation and protection of natural teeth, only gold inlays have **all** these advantages:

- Withstands forces of mastication
- Protects natural enamel

- Strength of Gold supports tooth pillars, — enamel rods.

- Protects against splitting force
- Restores contour and function of tooth

- Non-irritating to gum tissue
- Prevents periodontal disease

- Maintains better margins
- Preserves contact with adjacent tooth

Modern inlay golds are made in specific hardness, strength and toughness for particular applications.

Because of its long term economy and because it requires no more chair time than other materials and methods, a GOLD inlay is worth far more to the patient as well as to the Dentist.

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IN THE MATERIAL OF YOUR CHOICE

PLASTIC Biotone* Shades

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THEY'RE INTERCHANGEABLE

The freedom of choice that you have enjoyed in Flatback Facings is now yours in Trupontics.

The new Plastic Trupontic is made of a proved plastic, Biotone — hard — dense — color stable — and has the outstanding advantage — INTERCHANGEABILITY. When plastic is preferred, prescribe Steele's Plastic Trupontics.*

*Registered Trademark of The Dentists' Supply Co. of N. Y.

THE COLUMBUS DENTAL MANUFACTURING CO.
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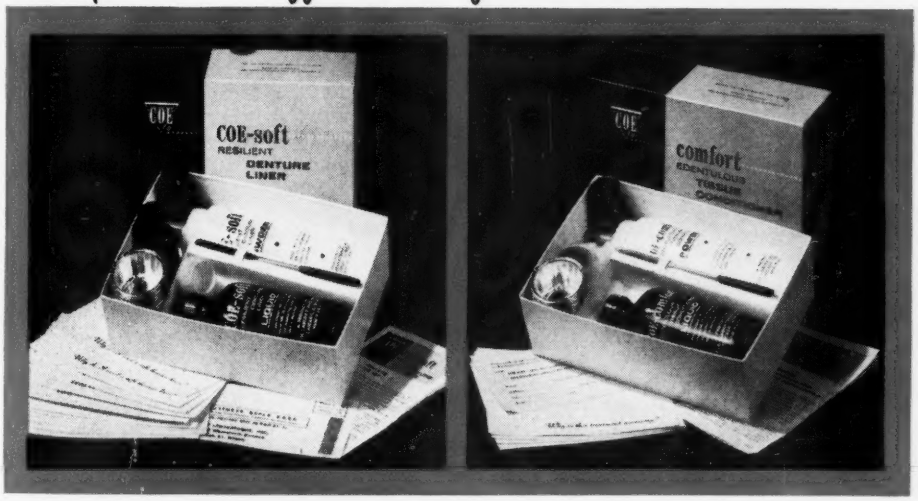
Steele's®

— For INCREASED comfort . . .

COE-soft . . .
the denture liner that makes dentures more acceptable & efficient

COE comfort* . . .
when dentures need a "lift" to restore healthy form and condition



COE-soft is indicated when patients cannot or will not wear restorations for physical or psychological reasons. It eliminates many problems, is especially useful when the tissue is thin, unyielding, sensitive, and easily irritated. May be applied to new or existing dentures quickly and easily. Package contains Powder and Liquid for approx. 26 applications, Bonding Agent, Lubricant, unbreakable measuring cups, mixing cups, directions, 12 brochures (for patients) "Why do I need a soft denture liner? "

COE comfort* is a new product of Coe research to assist you to restore the underlying tissues of your denture patient to a sound and healthy condition. Thus, your impressions of those tissues, which after treatment with Coe Comfort show improved physiological tone and color, will assure greater success for your denture service. Package contains Powder and Liquid for approx. 26 treatments, Lubricant, unbreakable measuring cups, mixing cups, directions, 6 brochures (for patients) "Why is this treatment necessary? "

* Patent applied for

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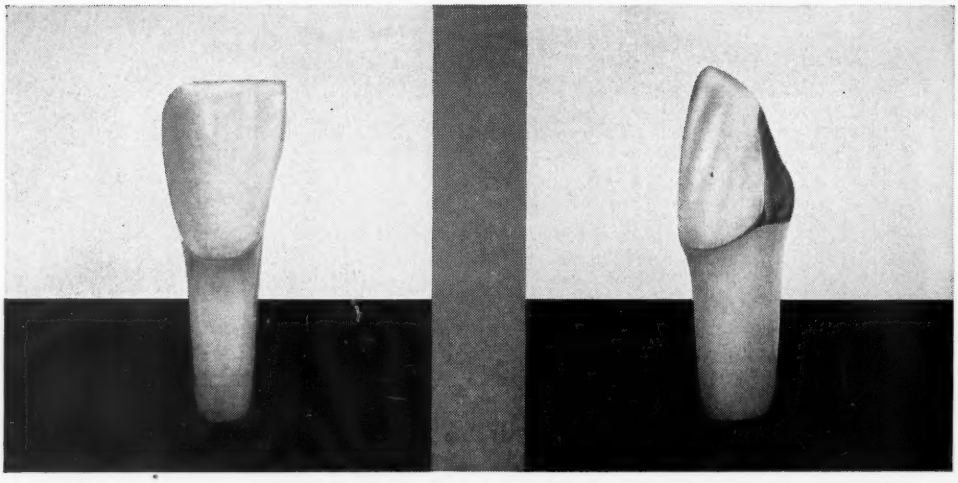
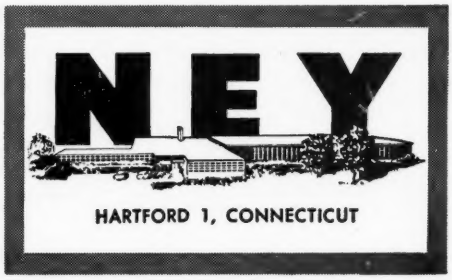


NEY-ORO P-16 CASTING GOLD FOR PORCELAIN TO GOLD RESTORATIONS

NEY-ORO P-16 is a hard, gold color crown and bridge alloy designed especially for use in porcelain fused to gold technics. The porcelain employed in combination with it should mature at a temperature of about 1800°F and should also be one especially formulated for gold-porcelain restorations.

The composition of NEY-ORO P-16 has been delicately balanced to provide the maximum bond between porcelain and gold with no discoloration of the porcelain. Repeated laboratory tests have shown that the bond is actually stronger than the porcelain so that when a composite structure is tested to destruction the break always occurs through the porcelain rather than at the interface between the metal and the porcelain. The strength of the gold is ample, even for long span bridges and is not reduced by repeated firings of the porcelain. In fact, repeated firing makes NEY-ORO P-16 stronger than in the "as cast" condition. Laboratory tests also prove that NEY-ORO P-16 has as high, or higher, resistance to corrosion in the mouth than the usual casting golds. To accompany NEY-ORO P-16, Ney has developed NEY-ORO P-16 Solder which flows at 1925°F, low enough to permit its being flowed over NEY-ORO P-16 Casting Gold (melting range 2020°F-2170°F); and high enough to withstand the firing of the porcelains whose firing temperatures are about 1800°F.

For those interested in the increasingly popular porcelain fused to gold type of bridge, Ney offers this thoroughly researched, thoroughly tested dependable team of NEY-ORO P-16 Casting Gold and its companion solder. *The J. M. Ney Company, Hartford 1, Conn.*



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These hands . . . and this analyzer . . . portray the wealth of technical skills and ultra-modern equipment that is yours through Mass Dental.

Every case you submit receives personal, individual attention . . . to infinite detail . . . by trained dental engineers. For over 37 years Mass Dental has continued to be one of the leading dental laboratories in America.

For guaranteed patient satisfaction send your next case to Mass Dental.

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CERAMICS **CAST PARTIALS**
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COMPLETE FULL MOUTH REHABILITATION

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Please send your complete portfolio of services.

☐ **Include mailing boxes and prescription pads.**

NAME .....

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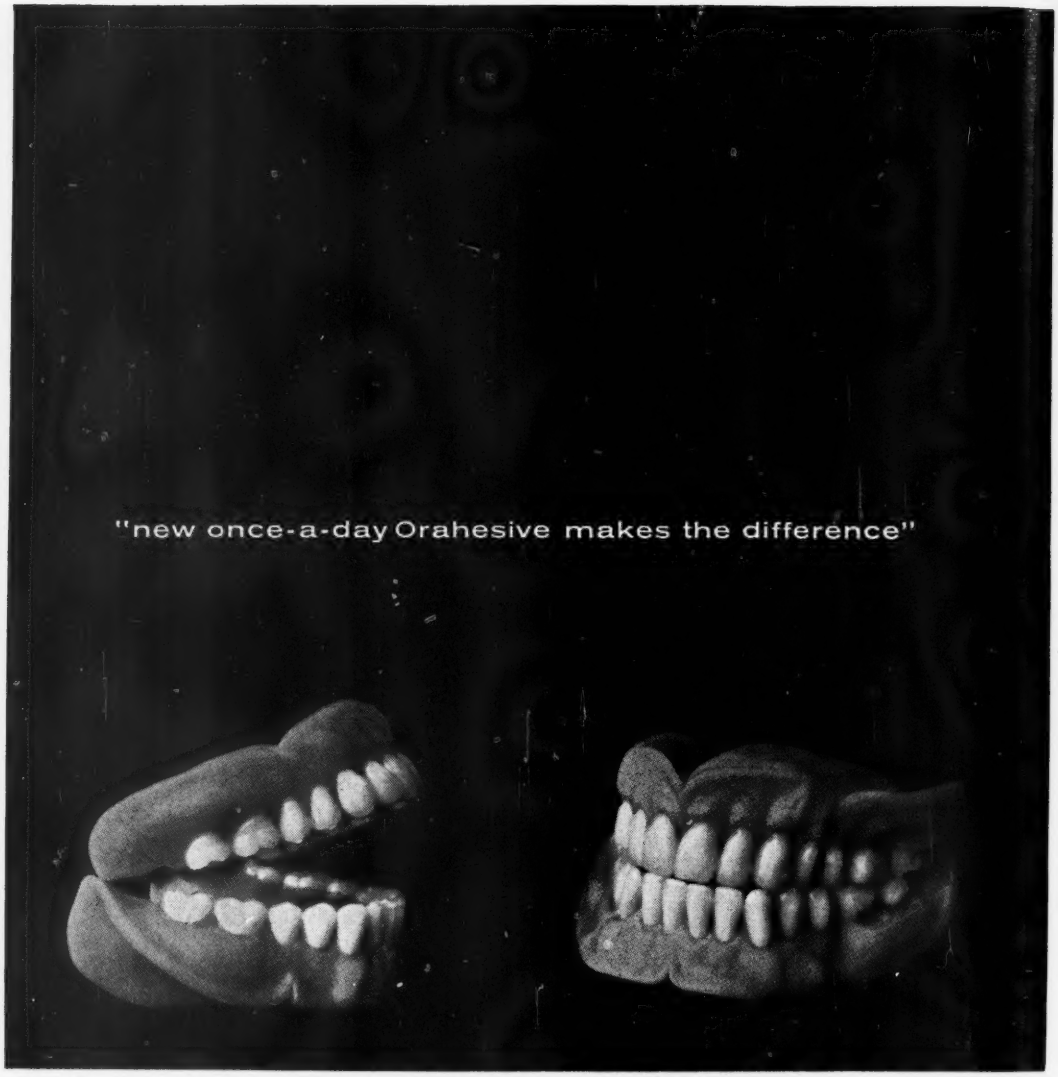
CITY ..... **ZONE** ..... **STATE** .....



The difference is in the unique Orahesive formula, a new concept in denture adhesives. Orahesive is a combination of pectin, gelatin, and sodium carboxymethylcellulose. Once-a-day application of Orahesive is usually possible because of its unique adhesive properties. Orahesive will not dry out or relax its grip, in contrast to gum karaya or the usual gummy preparations. Orahesive is a white, *tasteless* powder. It is not messy, and is easy to use. One simple application of Orahesive daily to wet dentures can prevent embarrassment, and it provides increased comfort for your patients.

holds dentures firmly all day

SQUIBB *Squibb Quality— the Priceless Ingredient.*

A PRODUCT OF SQUIBB RESEARCH IN DENTISTRY

Orahesive

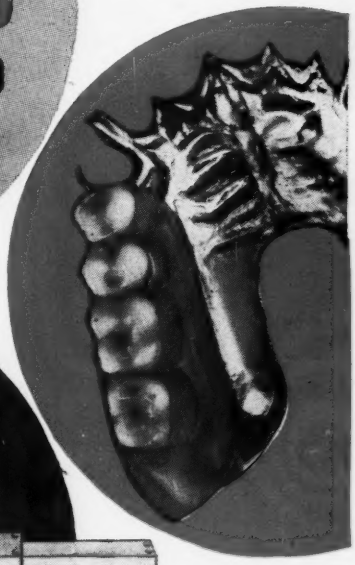
Squibb Denture Adhesive Powder

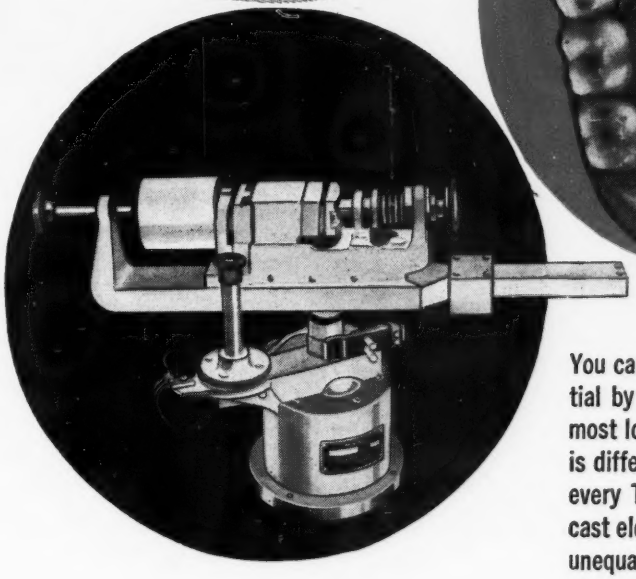
"ORAHESIVE"® IS A SQUIBB TRADEMARK.

EXCLUSIVE

electric casting

gives Uniformity to TICONIUM Partials





You can't tell a good partial by its looks because most look alike. Ticonium is different! For instance, every Ticonium partial is cast electrically providing unequalled uniformity. Insist on electrically cast Ticonium from your Ticonium laboratory.

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NEW SYMBOL OF TECHNICAL SERVICE TO DENTISTRY

To mark our 60th year of serving the dental profession we now proudly present this new identifying symbol

The listing of services below best indicates how the scope of our operation has expanded over the years . . . and how it continues to grow. We are proud to have kept pace with the progress in dentistry and with new technique development.

Dentists in all 50 States now avail themselves of our services. We take special pride in this recognition.

Increased recognition is the objective of our new symbol. However, we firmly believe that the value and quality of any service is best proven thru demonstration. To judge for yourself . . . consider some of the services listed below.

BOOS COMPLETE LABORATORIES OFFER THESE SERVICES...

Complete Dentures
Ora-Crylic "55"
Tinted Base
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Luxene
Hydrocast
Jectron
Soft Lining
Balanced Articulation
"Veri-thin" *Vitallium*
Art Craft

Partial Dentures
Precision Attachments
Vitallium and Porcelain
Gold and Porcelain
Vitallium and Acrylic
Gold and Acrylic
Stress Breakers
Wrought Surgiloy
Wrought Gold
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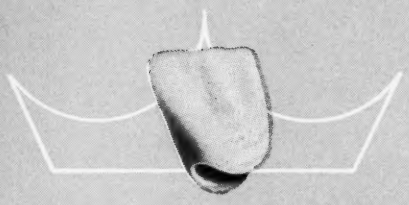

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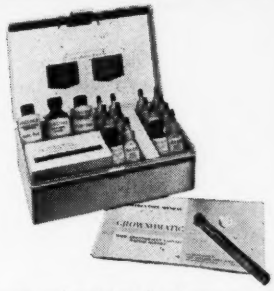

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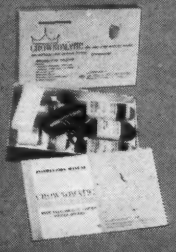

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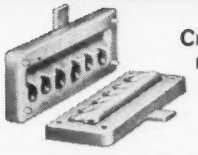

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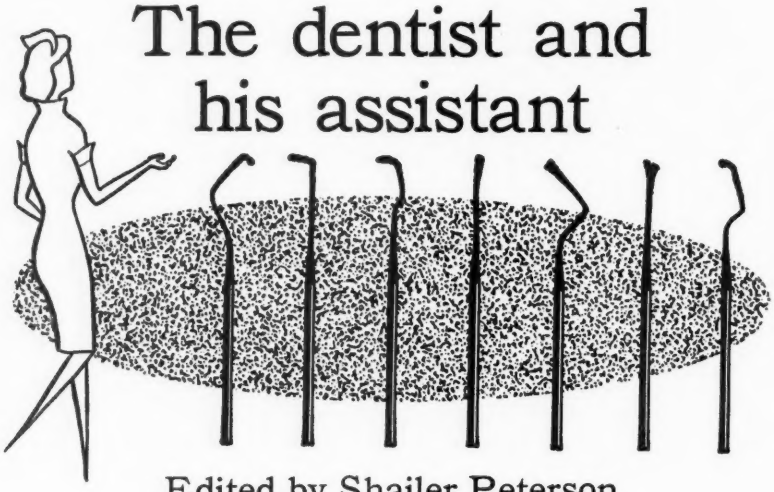

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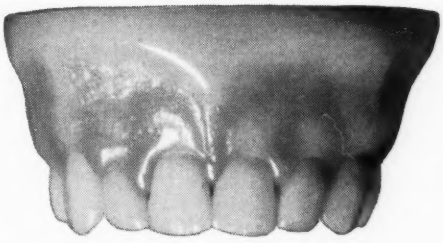

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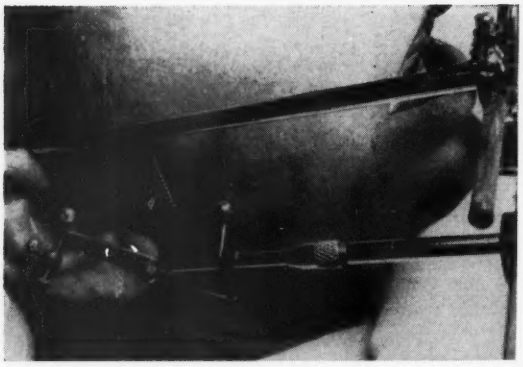

Fig. 94: Tip of stylus in relation to graph lines on flag. Patient in closed-jaw position.

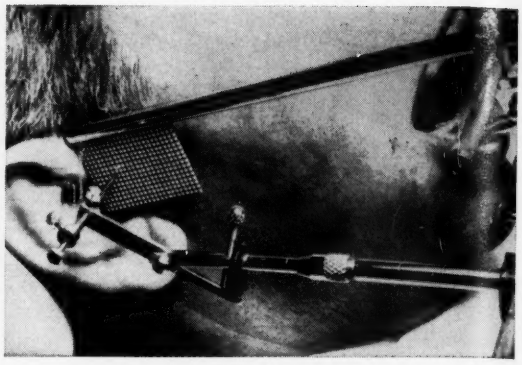

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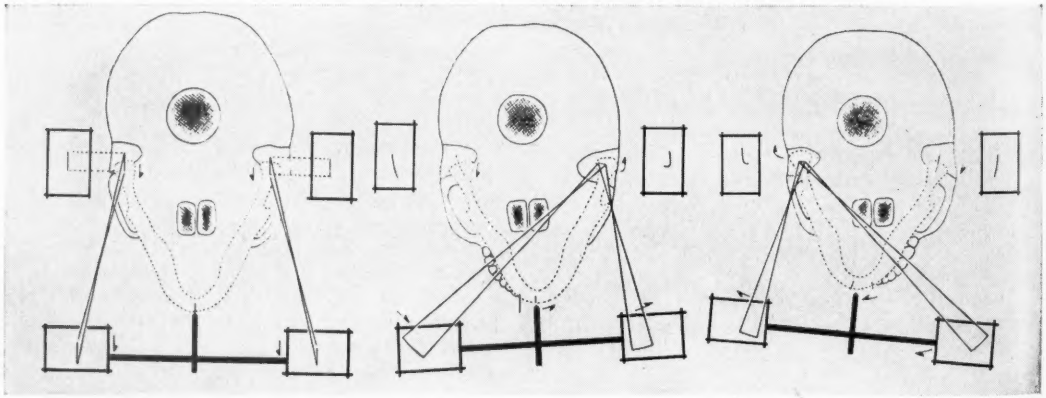
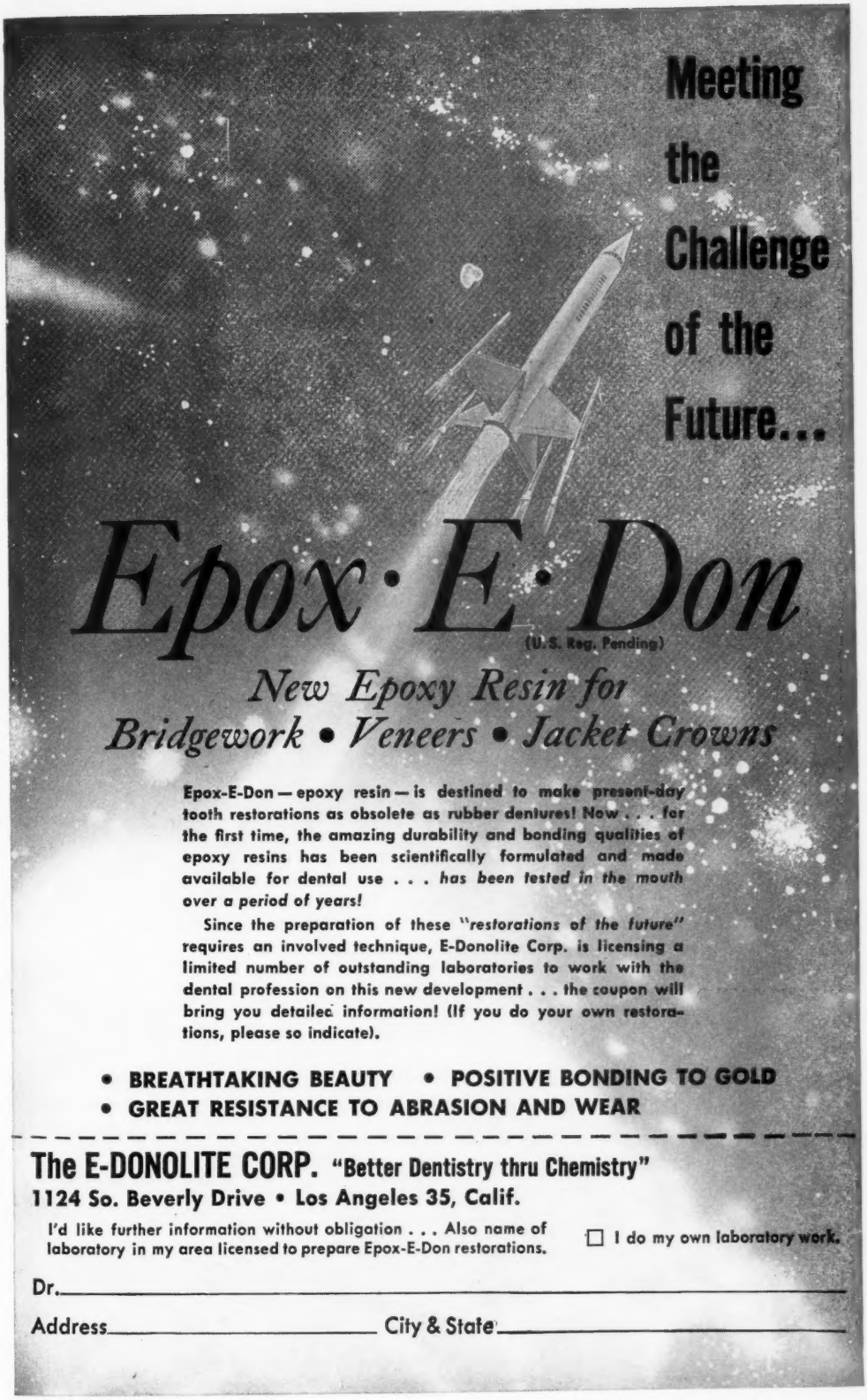
Fig. 155 (Left): Diagram of the pantographic tracings of a protrusive movement viewed from below. Note posterior tracings travel with the center of rotation; whereas the anterior seem to go backwards.

Fig. 156 (Center): Diagram of the pantographic tracing of a right lateral excursion. Note the sideshift of the pivoting condyle. Fig. 157 (Right) Diagram of the pantographic tracing of a left lateral excursion.

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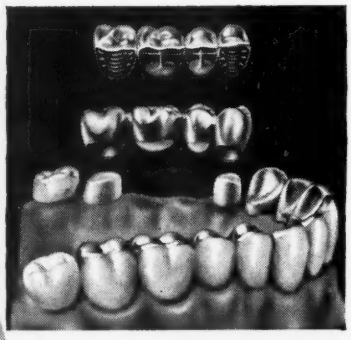

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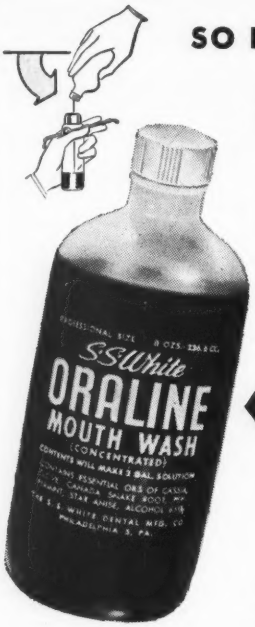

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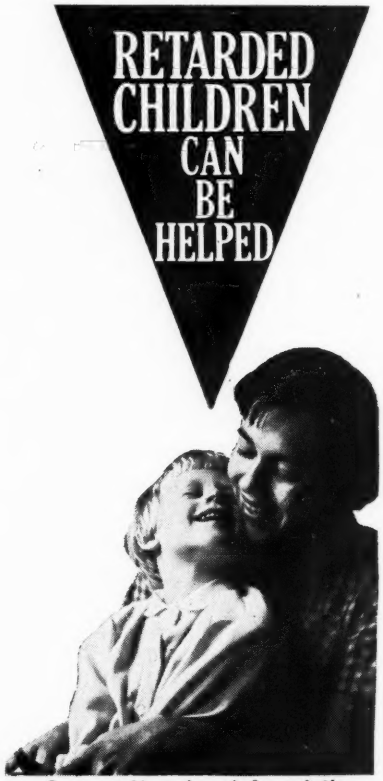

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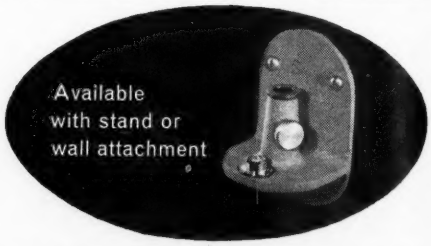

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